Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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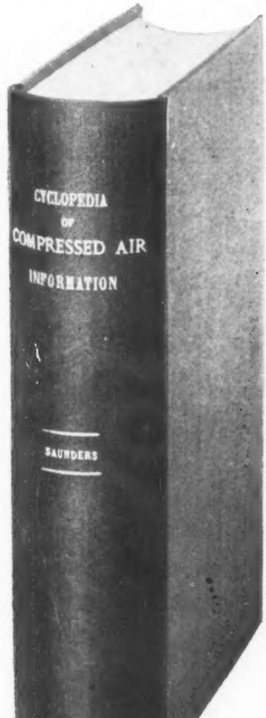

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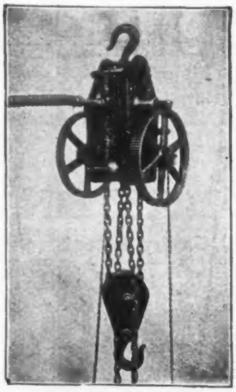

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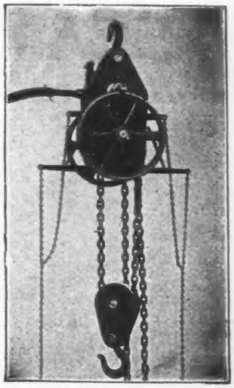

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W. L. SAUNDERS, - Editor and Proprietor
J. E. QUINTERO, - } Associates
M. E. VARIAN,

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Compressed Air in a Mine Disaster.

The importance and supremacy of compressed air in mining has again attracted attention in connection with the recent disaster in the mines of the Cambria Steel Company, near Johnstown, Pa. This coal mine, which has been considered comparatively free from gas and a safe mine was in some unaccountable manner involved in a serious explosion, resulting in large loss of life. It is reported that in one section of the mine after the explosion occurred no less than six or eight lives were saved by a happy thought which entered the mind of one of the entombed men. Knowing that an air pipe was used for conveying air into the workings, he groped his way through the darkness until this pipe was reached and with a pick succeeded in breaking one of the coupling joints, thus discharging health-giving compressed air into the foul, confined air of the mine. It is very likely that had more of the men thought of doing this in other sections of the mine, other lives might have been saved. This is not the first time that the air pipe has proved itself to be a life-saver. It so happens that this pipe when led into mines is of normal thickness and each section, as is well known, will stand considerable crushing strength, so that even after a serious explosion or fall in the mine, little if any damage is done to the pipe. Being of wrought iron, it is sometimes crushed out of shape, but even then it retains its capacity to carry air. Here we have the means by which air from the surface may be supplied to the inner workings of a mine after an explosion which has destroyed certain sections of the mine, cutting off chambers where life exists and making it impossible to reach the surface until rescued by a long and tedious process of excavation. This air pipe, it is true, is limited in its air capacity, but it is quite possible to increase the supply of air after an accident by concentrating all the air compressors upon one or more lines of pipe and for a considerable distance around the discharge opening in the mine noxious gases might be driven away and men may live for hours and even days. Another point which this mining disaster brings to our attention is the serious results which might follow the use of electricity in mines. It is impossible to always distinguish the safe mine from one that is unsafe. Gas seams may be perforated at any time, and where electricity is used there is always the liability of sparking which cannot be prevented, so that when considering the equipment of a so-called non-gaseous mine with electric machinery, it should not be forgotten that an accumulation of gas or fine dust might at any time be brought in contact with an electric spark with disastrous results. Too much importance cannot be given this subject, and we would not be surprised to see legislation directed against the introduction of electric power within the mine. Air is exactly what is wanted in a heading and electricity is just what is not wanted. So long as air can do the work of driving machinery in mines and do it with reasonable economy there is no excuse for the introduction of electricity. It has been established by years of experience that air can be used in mines with not only greater safety but with greater economy, and that with the single exception of lighting it serves every purpose for which electricity might be applied.

The McCann Spreader Car.

The report of the committee on roadway, submitted to the annual convention of the American Railway Engineering and Maintenance of Way Association last month, divides spreader cars or bank levelers into two principal classes, as follows: "First, those in wnich the wings open downward and outward, with hinges horizontal, and are handled either by a windlass or air pressure; second, those in which the wings fold against the sides of the cars, with a vertical hinge near the front of the car. In this class the wings may be adjusted for height."

It is a car of the first-class that has been used on the Gulf, Colorado & Sante Fe., and other roads. This car was designed by Mr. E. McCann, now general supervisor of bridges and buildings for the Atchison, Topeka & Santa Fe Ry., and was built for the purpose of spreading material plowed from flat cars to raise embankments in the work of grade reduction. Since that time six additional cars of the same type have been built, making seven now in service, on the following roads: The Gulf, Colorado & Santa Fe Ry. has one, the Atchison, Topeka & Santa Fe Ry. has three, the Southern California Ry. has one, the Chicago, Rock Island & Pacific Ry. has one, and the Colorado & Wyoming Ry. has one. Experience with the original car, built for the G., C. & S. F. Ry., has led to improvements in certain details of construction, although on general lines the cars recently built are similar to the original pattern. The purpose of this article is to describe the improvements that have been made, and to refer more particularly to the character of some of tne heavy work which the car is able to handle.

Briefly described, the operating mechanism of the car consists of a pair of wings hinged at the floor line, on each side of an ordinary flat car. These wings are constructed of 4½-in. oak plank faced with steel boiler plate and are supported at the back by struts bearing against heavy timbers extending across the car, underneath the sills. To stiffen the wings longitudinally they are braced with angle irons between the struts. The front section of the wing is hinged to a heavy bar extending diagonally across the corner of the car, and when the wings are let down for service this section overlaps the rear section. To prevent damage to the wing or dislodgment of the same in case a hinge should break, a chain is attached to the rear section to take the longitudinal stress in case of necessity.

The wings are lifted by means of air cylinders arranged on a beam running lengthwise the car and supported upon A-frames at each end of the car, at a height sufficient to clear the wings in their raised position. On the first car built there were four 8-in. air cylinders for this purpose, but on the improved cars there are two air cylinders, each 14 ins. in diameter and 6½ ft. long, with a piston travel of 6 ft. As the wire cable which hoists each wing is doubled around a pulley at the end of the piston rod, the end of the cable is pulled twice as far as the travel of the piston. The air for operating the wings is taken from the air brake system of the train and stored in a reservoir having a capacity of 57½ cu. ft. In lifting the wings they are raised to a vertical position, from which they swing over to a bearing against the forward A-frame, and a vertical post on the middle line of the car. In putting the wings into service they are pushed outward past the vertical position by two 7-in. air cylinders. In dropping to the service position the fall is cushioned by admitting air to the large cylinders at the top.

This use of the air, which controls all the movements of the wings, is manipulated by one man, who stands on the car floor at the right side of the storage reservoir, located at the rear of the car. The action of the top cylinders in lifting and lowering the wings is similar to that of a steam hammer, air being admited to one end of the cylinder for lifting the wings, or into the other end to cushion their fall, or to stop them at any desired point. The time consumed in dropping the wings to the service position or in lifting them from the service position to fold against the supports on the car, is only four seconds. In passing bridge floors, cattle guards, etc., the wings can be raised and lowered again without stopping the train.

In operation the front section of the wing clears the material from the rail. and out as far as the ends of the ties, and the rear section spreads it from the ends of the ties outward. The rear section is usually arranged to cut to a depth even

with the bottom of the ties at their ends, and to form a gentle slope from this point outward. The spread of the wings is 13 ft. 8 ins. on each side of the center of the track. When it is desired to cut the bank down to form a shoulder a steel templet of proper shape to trim the material to the desired cross section is attached to the outer part of the wing.

In the case of the car built for the Colorado & Wyoming Ry. the weight of all the apparatus which is attached to the naked flat car is 22,600 lbs., of which 10,400 lbs. are carried by the forward truck, and 12,200 lbs. on the rear truck. In constructing these cars a ballast box was placed at either end, with the idea that ballast might be needed to hold the car to the track while in service. In practice, however, it has been found that this ballast is not needed, and none is used. These ballast boxes are used as a place for storing chains, templet plates, tools, etc. The construction of the wings, leaning as they do from a vertical position, and sprung at the lower edge, and backed by struts hinged from above, is such as to give them a downward draft when plowing through material, the action being similar to that of a plow point. This draft assists in holding the car down to its work, which is not the case with wings which stand vertically, and explains why ballast loading is not needed.

To prevent the end of the front section of the wing from scraping against the rail, and to carry it safely over rail braces and joint splices, the machine has been improved by placing a wheel at the front end. When the car is in service the side pressure of the earth crowds the wing over, so that the wheel then takes a bearing on the rail.

The air contained in the storage reservoir is sufficient for four applications of both the large and small cylinders. The first application reduces the pressure in the reservoir only four pounds. The pipes which feed the top cylinders are only ½ in. in diameter, so that the flow of air is not sufficiently rapid to do damage to the machinery in case an inexperienced operator should open the cocks too suddenly. As the pistons are of large diameter, the wings when free from dirt are lifted without admitting full reservoir pressure, the cylinders being designed with a capacity sufficient to lift the wings when plowing through dirt the full depth, and then when the train is in motion. There is an automatic valve to prevent the reservoir from being emptied in case the train should pull apart and break the hose connection.

In actual service this car has spread earth at the rate of 17,000 cu. yds. per hour, all the operations of the car being handled by one man. In one instance the car, starting from a standstill, dropped the wings and spread 176 car-loads of earth, carrying from 20 to 30 yds. to the car, in 13 minutes. Either one or both sides of the car may be used as desired. The stability of the car when spreading from one side only is sufficient for heavy work. In numerous instances two engines have been used to pull the car when it was spreading from only one side. So long as there is sufficient tractive force the car will plow its way through heavy gumbo or rock without difficulty. In leveling down rock large stones weighing from one to two tons have been handled without trouble. During the past year one of these machines spread 358,316 cu. yds. of earth and rock.

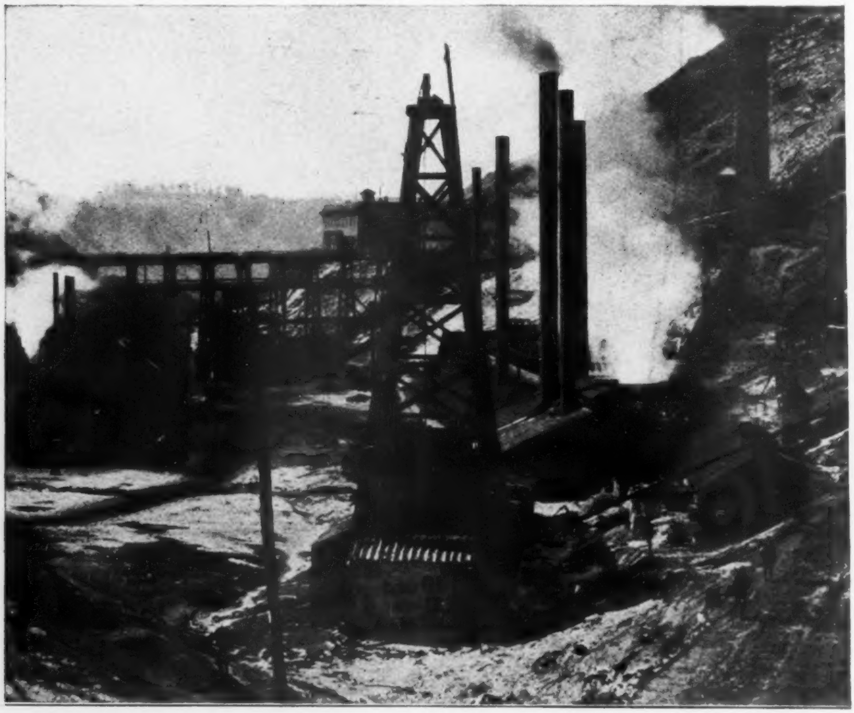
The construction of the machine is covered by patents, and the entire management of the manufacture and sale of the machine is in the hands of Mr. O. C. Mann, 3032 Monroe St., Chicago.—*The Railway and Engineering Review.*

A New Deep Pumping System in the Far West.

A very successful application of the pneumatic principle has just been made at Cambria, Wyo., by the Cambria Mining Company, in which a column of water is lifted 1,850 feet in one straight lift, an accomplishment that is something new in mechanical operations. The principle is not entirely new, for there are a few instances where it is in successful operation to a depth of 500 or 600 feet, but so far as known to the operators and the writer, this is the only well where it has been operated to such depths. Two months ago the well was completed to a depth of 2,300 feet, at a cost of $25,000. The well starts at the coal horizon, near the openings to the mines, which produce the coal for the B. & M. railroad system, and was put down for the double purpose of increasing the water supply necessary to operate the mines, and also to prospect

the underlying strata. After passing through sandstones and shales, prior to the coal producing period, a hard limestone was encountered when a progress of only from one to two feet a day could be made. It is believed that nothing of importance in the way of lower coal seams was discovered, and the oil sands of the New Castle fields, which is seven miles to the south and on a lower level, are known not to enter the foothills but a short distance,

The water, on analysis, proved very acceptable for boiler and domestic uses, so 2,000 feet of one-inch pipe was ordered. The larger casing in the well was removed and replaced by a four and five-eighths inch casing, and the inch pipe, after connecting with the high pressure compressor, used in the haulage system underground, enters a T joint at the top of the well and flows down inside the casing for a distance of 1,700 feet from the surface.



AIR-LIFT WELL OF CAMBRIA MINING COMPANY, WYOMING.

so the product of the well is confined to water. No flow was experienced, and the water only rose to within about 200 feet of the surface. It was with a spirit of experimenting that the pumping system was put in, for all of the most experienced compressed air men of Denver were outspoken in their belief that such a feat was beyond the realm of possibility.

This air line is reduced near the bottom to three-fourths inch, and the lower end is turned upwards and drawn out to a half-inch opening, forming a nozzle through which the compressed air makes its entrance under a pressure of from 800 to 1,000 pounds from the compressor. When the air is first turned on there is a column of water from the 1,700 up to the 200-foot level, and it requires about

15 minutes for sufficient pressure to accumulate in the empty air line and at the bottom of the well to start this immense column of water in motion. The back pressure at this point on each square inch would be equal to the weight of a column of water one inch in diameter and 1500 ft. in height or 645 pounds per square inch. The air pressure at 800 to 1,000 pounds is nearly twice the back pressure of the weight of the water, so that when once in motion it raises the 1,700 feet in the well and the 150 additional feet to the reservoir on the hillside, at a dreadful velocity, and at a rate of 1,000 gallons per minute, which it is only unable to maintain on account of the well failing to supply more water at the same rate. After this first terrific rush of water and the almost deafening roar that follows it, as the expanding air that follows it is being discharged, the well flows intermittently, first a short column of water and then a discharge of air. Before the discharge pipe was carried up the hill to the reservoir tank, as shown in the illustration, it was allowed to discharge in a horizontal position near the ground. To the eye it looked as though the other end of the pipe must be drawing in one of London's famous fog banks, for the only appearance of anything resembling water was the stream that collected on the ground under the white mist. The rapidity of the flow is regulated by the size of the opening admitting the air. Two orifices are used, one five-eighths of an inch, which gives a flow of 120 gallons per minute, and another seven-eighths, which raises the discharge to 200 gallons. If the well replaced the water with greater rapidity it would be interesting to know the maximum capacity of this method of pumping. It is certain from the first discharge that it would not be less than 1,000 gallons and probably several times that amount. The first test made was done with the five-eighths inch, and the air turned on for 90 minutes, including the first 15, during which nothing was discharged, the flow measured up 109 gallons per minute. It has long been claimed by authorities that liquids could not be raised in this manner unless there was a certain amount of back pressure. In this well, of course, it is impossible to determine the amount of water left above the nozzle when the flow is exhausted, but in other shallow wells the water has been almost if not entirely blown out by the management. With insufficient pressure, of course, such as atmospheric air, the gas would climb through the liquid in bubbles, but when the elasticity is sufficient, which is acquired by increasing the pressure, the air bodies withstand the tendency of the liquid to drop back through them, and then as the diameter of the water column is increased, the volume of the air supply must be raised correspondingly. Of the cost of operating this well, the exact figures have not been determined. It is certainly very little, for the high pressure compressor was already installed for the use of the traction engines. Just how much air is required is not known, only approximately, in comparison with that used by the engines. When one of the latter is charged the pressure is reduced in the pipe line 50 pounds. When the well is started, the pressure only falls 12 pounds, and the steady consumption is known to be much less than that of one of the engines, but how much less has not been determined. These engines are 40 horse power, and consumes 120 cubic feet of air per minute. This method has been tried in the oil fields to a depth of about 400 feet. It raised the oil more rapidly than water, but was not a success for two reasons, the action of the oxidizing power of the air tended to coagulate the oil, and the back pressure of the combined oil in the column and the air interfered with the flow of oil, and in some instances temporarily stopped it altogether. It is, however, an unquestionable success when an artesian well will not flow.—*Western Mining World.*

Compressed Air in Mining.

FOR DRILLING, HAULING, HOISTING AND PUMPING.

Three general classes of air compressors are used for mining purposes—those that are steam driven; those that are water driven; and those driven by electric

motors. They all may be either simple or compound. The general arrangement of the cylinders is not of great moment; that is to say, it matters little whether the compressor is duplex, cross-compound, tandem-compound, or of any one of three or four combinations, provided that the cylinders are disposed in such a manner that the work of the motor will be a minimum.

The best known and simplest form of compressor is the so-called straight-line machine in which the air cylinder is directly behind the steam cylinder and one piston rod connects them both. This form of compressor is, as a general rule, not desirable, for economical reasons, for an equipment of more than 50 or 75 horse-power, and, for powers up to 150 horse-power, should be replaced by a compound machine of a similar type. For larger machines it would seem that a Corliss engine would be better calculated for economy, either simple or compound or compound condensing, according to the power and the opportunity for obtaining condensing water.

It naturally must be assumed that at this time, when the conservation of power seems to be an important consideration, a mine which has to convert so large a portion of its power into compressed air will do so with economical machines. It seems useless to discard the more expensive fuel and encourage the water-power companies who offer cheaper power, if, after that power has been obtained, no effort is made on the part of the mine management to take advantage of it for the larger powers, and the writer has this fact in view in placing the various kinds of compressors in the order named.

For compressors driven by water-power the simpler forms are plain air cylinders, operated by belt or gearing from impulse water-wheels. This type should not extend beyond 50 horse-power, at which point the compound machine should take its place, and no improvement upon this form can be suggested, excepting that, where the opportunity offers, it is always preferable to have the water-wheel direct-connected on the compressor shaft. This practice eliminates many objectionable features, principally the cost of separate foundations, saves space, a separate fly-wheel and the maintenance of belt or gears.

It has been generally assumed that this practice has mechanical limits, within ordinary conditions, but the writer has not found this to be the case. The excessive diameters of these wheels, due to the fact that the number of revolutions should be small, has been an apparent barrier to their employment for heads of water above 500 feet, and the first wheel employed for a head of 700 feet and 100 revolutions, which called for 19 feet in diameter, was undertaken with some hesitation. The ease, however, with which it performed its work, justified the construction, later, of one of 22 feet, following which came one of 25 feet, another of 30 feet, and later still one of 33½ feet, the latter operating under a head of 1,400 feet. This wheel has satisfied all expectations.

It can readily be seen that in wheels of this large diameter, where the principal weight is concentrated in the rim, and with a jet under tremendous heads impinging from one or two nozzles upon the buckets, the fly-wheel effect is perfect and a much lighter wheel may be suspended on the shaft to give the same general effect as a heavier fly-wheel. Another advantage in having a direct-connected wheel, where compound compressors are used, lies in the fact that the water-power in the tail race and the spray from it may be used very advantageously for intercooling without using an excessive length of pipes.

In compressors driven by an electric motor new conditions are encountered. Most of the motors used are induction or synchronous motors, which run at practically constant speed. In the other classes a system of governing can be applied to the speed of the machine for the conservation of power, while with the electrically-driven compressors the speed must be constant and there must be some other means of regulating the duty. This is found in what are termed variable volume machines—that is to say, machines which are so governed that they compress more or less air, depending upon the requirements of a mine. This is generally done, and is eminently successful in handling the quantity of air and at the same time relieving the compressor from undue service. Nothing is more objectionable than the continual blowing off of air from the receiver and nothing is more wasteful of power. In addition to the classes above mentioned, compressors are also driven from line shafting in mills, but these are generally of small capacity; otherwise the

uniformity of motion demanded by the mill would be seriously disturbed.

The principal uses for compressed air in a mine are for running rock drills, for shaft sinking, drifting, stoping and upraising, and pumping. It has generally been considered good practice, depending upon the hardness of the material encountered, to use for shaft sinking either the $3\frac{1}{8}$, the $3\frac{1}{4}$ or the $3\frac{1}{2}$ inch drill; for drifting, either the $2\frac{3}{4}$, $3\frac{1}{8}$ or $3\frac{1}{4}$ inch machines; and for stoping, either the 3-inch, $2\frac{3}{4}$ or $2\frac{1}{4}$ inch machines. There are mines that use a $3\frac{1}{2}$-inch drill for stoping, but it would appear to the writer that a smaller size would be more economical.

The average shaft drill consumes from 100 to 120 cubic feet of free air per minute, compressed to about 90 pounds; the average drill used in drifting consumes from 70 to 100; and the average drill for stoping consumes from 40 to 70. In general, while holes are drilled very frequently to a depth of 8 feet, they average about $4\frac{1}{2}$ feet, and the size of the hole is such as will permit the use of sticks of powder of from 1 inch to $1\frac{1}{2}$ inches in diameter.

The average work of a rock drill for one shift is from 30 to 40 feet of holes drilled. It is generally assumed that a good rock drill will do the work of from six to ten men. It takes from five to twelve horse-power to furnish a drill with compressed air, and with the exception of what are known as "Baby" drills, it takes two men—a machine man and his helper—to operate a machine.

Air is furnished to the drills through pipes leading from the shaft into the drifts or stopes. In general, these pipes are too small for the work intended. In the average mine, not knowing just how far drifting will be continued, too small a provision is usually made for the diameter of the branch pipes, and often such a pipe, laid in a drift originally for the sole purpose of running rock drills, is tapped to operate a winze hoist, and after that a pump in the winze, and very frequently for operating fan engines, so that often with ninety pounds pressure at the surface, a rock drill will not receive over forty to forty-five pounds in its cylinders. This lessens its proper work to a marked degree and increases the cost of the output of the mine. It always pays, whether operating one drill or more, to put in a pipe of sufficient size to give very nearly full pressure at the drill.

Most of the standard drills are reliable in character and are good enough for performing proper service in a mine. The man behind the drill practically determines how much work the drill will do in a shaft. A poor machine in the hands of a good workman will do more work than if the situation were reversed. For economy in mining a first-class machine man should be given a good drill and one of proper size for its work, and he should be permitted to repair his drill often enough so that the machine will expend its energy upon the rock instead of jumping about on a loose clamp, a worn-out feed-screw or loose guides.

Too often the economy of a rock drill is judged by the amount of repairs it takes, though these may or may not be the fault of the machine; but, in any event, this feature should not be taken into consideration.

From an experience of something like twenty years with drills the writer finds it impossible to make a proper comparison between different kinds of drills operating at different mines, and even in the same mine two different drills should be operated at the same time and in the same drift by equally skilled men in order to permit making a fair comparison. After keeping tabulated lists for a number of years the writer finds that of the standard makes of drills, having the same weight and the same diameters of piston and piston rod, there is practically no difference in cost of repairs per foot of holes drilled during the month. The repairs on a drill are so insignificant with respect to the cost of running the drill that they may be neglected, and one's thoughts and energies should be concentrated on the other features of expense attached to their operation.

One mine that has come under observation and which keeps a very complete record of its operations, pays \$3 a day for a machine man and \$2 for a helper. These wages average 16 cents per foot of hole drilled; the power averages 5 cents per foot of hole drilled; the breakage and repairs are about 0.06 cent per foot, making a total of 21.06 cents per foot. It will be noted that the cost of breakage and repairs is only one thirty-sixth of the cost of drilling the holes, or less than 3 per cent., which may be neglected and atten-

tion given to the more important elements of wages and the capacity of the drill.

In the above record the average is 38 feet of holes per shift per drill. There were two shifts per day, making 76 feet per day, or 2,280 feet per month, for one drill. The cost of breakage and repairs on these drills during the month, at 0.06 cent per foot, would be $13.68, and this is about what it ought to be.

Now, if the repairs and breakages are $13.68 for drilling 2,280 feet of rock, then in order to offset this expense by extra service of the drill it would be necessary to drill during the month only 65 feet additional, at 21 cents per foot. If it is desired to gain 65 feet in a month where 2,280 feet are being drilled, it would mean that there would have to be a gain on each amount of holes drilled of one-third of an inch, or, practically, if another machine man or another drill were substituted and either the man or the drill advanced the record one-third of an inch to the foot, it would entirely cover the cost of keeping the drill in repair.

It will be seen from this what an insignificant item the matter of breakage and repairs is on a rock drill in comparison to the actual cost of drilling the holes. In contrast to this small expenditure it would be well to note that the amount saved to the mine by either a drill or a drill man who could drill, for example, 15 per cent. more than another, is very considerable. Taking the previous figures, where 2,280 feet of holes were drilled, an advance of 15 per cent. would mean a gain of 342 feet of holes, which, at a power and wages cost of 21 cents per foot, would be $71.82, so that at the end of two or three months a mine would save the cost of an extra drill.

From these facts it is naturally deduced that the first cost of a rock drill may be given no great consideration; the amount of repairs necessary to keep a rock drill in operation may also be given no great consideration; but the number of feet of holes it will drill in a month is the real consideration, and in a competition or comparison between different men or different drills the basis should be the cost per foot of holes drilled, this cost to be made up from the power of cost of operating the machine plus the wages and the repairs.

The "Baby" drill, having a cylinder 2¼ inches in diameter, with a 4 or 5 inch stroke, is one which is at present demanding a great deal of attention from mine operators. It has been supposed that this drill had not sufficient power for general mine work on account of the vast difference in weight and strength of its various parts, as compared with the ordinary mine drill; but in certain California mines especially these little drills, made of steel, are drilling in hard metamorphic rock holes 8 feet deep at a less cost than with the larger machines, and one large mine has laid aside the larger drills entirely, excepting for shaft work.

The advantage of the "Baby" drill lies in the fact that it is a one-man drill, which cuts off at once one-half of the principal cost of operation. Its exceedingly light weight, viz., about 100 pounds, permits it being easily carried in stopes and in upraises, and its small size permits it to be used in close quarters. It takes less than one-half the air to run a "Baby" drill than one of the larger machines; consequently the air conduits are less expensive and easier put in place.

There seems to be very good reason why the smaller drills should fulfill many of the requirements of the larger machines, and in many places the selection of the size of the drill has been on a wrong basis. Sticks of powder about 1¼ inches in diameter are an average of the sizes used. It is, therefore, not necessary that the bottom of the drill hole should be any larger than 1¼ inches. Allowing five different lengths of drill to reach the bottom of a 5-foot hole, and allowing ⅛ inch clearance to each successive drill, it is evident that the hole need not be started larger than 1⅞ inches, and there is no need of wasting powder or employing a drill heavy enough to drill a larger hole.

The larger the drilling machine, the larger the steel that has to be used with it to prevent it from buckling; and the larger the steel, the larger must be the diameter of the hole in starting, so that in many instances the ratios of the diameters of the drill cylinders to the diameter of the holes required for starting are such as to offset the advantages of the larger cylinders.

At a mine near Sonora, in California, the owner states that he is operating one "Baby" drill with a compressor driven by a gasoline engine. One man succeeds in drilling ten 4-foot holes in ten hours, at an expense of four gallons of gasoline, costing twelve and one-half

cents per gallon. This is a remarkably cheap performance for drilling holes in hard rock.

Compressed Air for Mine Haulage.—When the distances in a mine become great the cost of tramming ore and waste becomes quite an item. The length of time necessary for a round trip makes it difficult to handle the quantity, and man haulage gives way to a train of cars hauled by animals. Steam motors cannot be used, on account of their heat and smoke.

During the last ten years a great many miners have replaced animal haulage with compressed air motors, which lend themselves splendidly to the work desired. There are, in general, two systems—the low-pressure system, in which air is compressed to five or six hundred pounds; and the high-pressure system, with air pressures of 2,000 pounds and over. The former system can be used in large galleries or tunnels or drifts where the width is ample and the track is reasonably straight. This permits a large receiver on the motor, 30 to 40 inches in diameter and from 8 to 16 feet long, to be handled with ease. The high-pressure system is used where the drifts are narrow or the curves on a small radius, permitting only a small wheel-base on the motor. Large receivers are, therefore, impractical, and steel tubes must be used and charged with high-pressure air to get sufficient volume.

Compressed air may be used cold on either of these motors, or the air may be passed to small tanks of hot water supplied to the motor at the charging stations.

The air and hot water combination does almost double the work that cold air will do. These motors can carry sufficient air for any ordinary run desired and haul tremendous loads. Two miles and return, with fifteen or twenty loaded cars. is not an extraordinary effort, and from the general results obtained, the cost of haulage is from one-half to one-third of the cost of the animal power. The air escaping from the exhaust of the motor engines adds to the ventilating effect in the mine and the whole system harmonizes thoroughly with the power outfit in the average mine.

During the year 1900 the writer was given the opportunity at the Morning Mine, at Mullan, Idaho, U. S. A., of installing upon their property a typical modern mining plant and one which contains most of the salient features that are considered important in compressed air engineering. A brief description of the plant, which, aside from being interesting from a compressed air standpoint, employs now the largest tangential water-wheel in the world and shows how three different heads of water can be harmonized on one compressor shaft, may not be inappropriate here.

The considerable cost of fuel to operate the steam-power compressors at the mine determined the management to utilize the water-power in the neighborhood to drive a compressor large enough for future needs. Surveys of possible water-power were made long ago, and eventually a site was determined upon near Mullan which made it possible to utilize three water-powers; first, that of the Cœur d' Alene River, by building a a dam and headgates just below the Morning mill and carrying the water in a flume to Grouse Gulch, giving 140 feet of pressure; second, by taking up the headwaters of Grouse Gulch and conducting them to a favorable point so as to obtain a fall of 1,420 feet; third, by similarly taking up the waters of St. Joe and Rock creeks and obtaining a head of 1,140 feet. The total capacity of these three sources would give a minimum of 1,100 horse-power during the season of the lowest stage of water.

The river flume is built of planed lumber, and battened inside and covered. It is 5 feet wide by 4 feet high in the clear and about 8,000 feet long, delivering into a steel pipe 42 inches in diameter and 400 feet long, reaching to the power-house. The Grouse Gulch pipe line is 7,350 feet long, containing 2,000 feet of 9-inch and 5,350 feet of 8-inch standard pipe. The Rock Creek water-line consists of 2,645 feet of 8-inch standard pipe. All of these lines are well anchored and completely buried.

The compressed air line consists of 9,500 feet of 12½-inch inserted joint pipe, which reaches to what is known as Station No. 6. From there two 9-inch branches are made, one into the No. 6 tunnel, which, when completed, will be 10,200 feet long, and one branch of 9-inch pipe to No. 5, 11,700 feet long and into No. 5 tunnel 1,500 feet, making a transmission of 22,700 feet to the present workings.

The compressor is designed to run 100 drills, and, owing to conditions relative

to power, has offered a very interesting problem in compressor construction. On the main shaft of the compressor is mounted, as previously stated, the largest tangential water-wheel in the world, being about 33 feet in diameter. The rim is made very heavy to serve as a fly-wheel, and the diameter is a compromise between the requirements of the two higher heads, taking eighty revolutions of the wheel as the standard number of turns. This wheel will give the tremendous rim speed of more than 8,000 feet per minute, which has required special construction of the highest grade.

Two separate pipe lines convey the water to the nozzles at the periphery of the large wheel, and each nozzle is controlled by a suitable high-pressure gate valve and its by-pass, to prevent shock to the pipe line. The nozzles also have deflectors, so that the water streams may, in an emergency, be thrown from the wheel by the station operator. On the other side of the large wheel are two 11-foot Pelton wheels to receive the water from the Cœur d' Alene River, at a head of 140 feet, the total capacity of these two wheels being about 1,200 horse-power.

The compressors are compound, compressing the air in the first stage to twenty-five pounds and delivering it into the mains at ninety pounds, the heat generated by the first compression being absorbed in a double set of intercoolers placed in the tale-race of the low-pressure wheels. The compressor cylinders are, respectively, 32½ and 18 by 42 inches stroke, so that the piston speed of the compressor is 560 feet a minute, which is practically the limit of compressing speed. While this speed might not be disadvantageous to a single-stage compressor where the delivery occurs at or near the end of the stroke, in a compound compressor for the above pressures the delivery valve must open at about the centre of the stroke where the piston speed is 50 per cent. higher than the average. The delivery valves are thus compelled to open when the piston is moving at somewhat over 800 feet a minute. This presented a unique problem for valve construction, which has been solved in this instance by a very complete and satisfactory valve gear. All of the foundations are elaborate and expensive and are three separate stories in height. They are pierced by tunnels, and will be lighted so that any portion may be inspected at any time.

The intercooler is unique in character, and consists of a large number of 1¼-inch brass tubes, about 18 feet long, in a reservoir of water situated in the middle story of the foundations, flooded by back-water from the low-pressure wheels. Perforated floors under the intercoolers permit continual circulation, and are arranged to take away any sand which may be deposited.

The compressor is also fitted with an aftercooler, and underneath the cylinders and main frames a wide channel in the concrete is made, through which water continually flows to take away the immediate heat from the discharge valves, and to take away the discharge from the water circulations and also the oil and dust refuse. Each cylinder has two independent water circulations and each head has an independent water circulation. No expense has been spared to make this a thoroughly first-class and satisfactory installation.

The plant has realized all expectations. The temperatures in the compressor are remarkably low, indicating efficient working. The pipe line is perfect, and was tested to 160 pounds water pressure before turning in the air. It is seldom that a compressor has an opportunity to pump into so large a reservoir, namely, 12,000 cubic feet at present, but which will be, later, about 17,000 cubic feet. At present the reservoir holds 100,000 cubic feet of free air at ninety pounds pressure, or about 10,000 stored horse-power, calculated on the basis of a reheated economical motor. It will be interesting to those who are contemplating compressed air transmissions to know that the loss in this four-mile transmission may be neglected. The Morning Mine closed down the old compressors and found, upon turning in the new line that it took about 2,000 cubic feet of free air to do their present work. This amount passing through the pipes showed no appreciable loss on the gauges. It was not one pound at the most.

Compressed Air for Hoisting.—Compressed air is used for hoisting, both inside of the mine and on the surface. Either steam or compressed air is preferable to other media for hoisting, and the majority of hoists are built to use either one or the other medium, and the fact

that they can be used in the same hoist proves an advantage in many places.

For underground work most of the hoists are small and are operated on winzes. Except in particularly favorable places, these hoists are operated with cold air, and are, therefore, not economical, as far as power is concerned; but they are extremely useful.

A winze hoist should be backed up by a large receiver near by.

Compressed air timber hoists are an extremely useful appurtenance for underground work. They are very light, weighing five or six hundred pounds, have small reels and small geared engines, and are of powers ranging from 5 to 10 horsepower. For hoisting timbers and drills into an uprise, or for hoisting timbers into stopes or around a mine generally, they are very useful. These hoists are also made on trucks so that they may be taken from one part of the mine to another very easily. All these underground hoists consume from 20 to 25 cubic feet of free air per horse-power of actual work done.

Surface hoists operated by compressed air are much in vogue, especially where the power is electrically transmitted to the mine. A portion of the electrical power is converted into compressed air to be used for the hoists. The most economical way to use this air is to so arrange the plant that the electrical power is practically constant and the compressor is just large enough to absorb this power. There must be large storage capacity, so that when the hoist is not in operation the power may be stored.

The hoist itself should be a compound, first-motion hoist to be a thoroughly up-to-date machine. A compound geared hoist is not quite so economical in air. The hoist cylinders should be jacketed. The air, after passing from the receivers, should go through a heater having two compartments, one for high-pressure and one for low-pressure air. In the first compartment the air is heated to about 400 degrees and passes around the jackets of the initial cylinder and finally into the cylinder itself, being exhausted from there back to the second compartment of the heater, where it is heated again to about 400 degrees, passes to the low-pressure cylinder of the hoist, and from there escapes to the atmosphere. A hoist of this character requires from 7 to 8 cubic feet of free air per horse-power, a vast difference as compared with the requirements of a cold air hoist. The cost of reheating is very small. The North Star Mine, at Grass Valley, Cal., using such a hoist, employs crude oil for heating purposes and consumes about a gallon an hour, which is insignificant in comparison to the power that this heating develops.

These compound, first-motion hoists are not expensive, even in first cost, and are extremely economical in operating. Large receiver capacity is an insurance against shut-down of the power plant, for unless the hoist itself gives way there will always be air enough on storage to bring the cage out of the mine, no matter what happens to the power plant.

Compressed Air for Pumping.—One of the most important uses of compressed air in a mine is for pumping, and within the limits of space the writer finds it difficult to properly consider the subject. Compressed air has been handicapped from the very beginning in the matter of pumping, because it has been used with stock pumps which have been designed in general for boiler feeding and tank purposes, and no particular regard has been paid to matters of cylinder proportions and appropriate pressures. Steam and compressed air are not similar enough in their phenomena to be used in the same motor.

The various rules and tables offered for calculating the amount of air required to lift water, without proper explanations, lead to the almost general conclusion that compressed air is a very expensive luxury. The percentage of efficiency credited to compressed air in the ordinary tables ranges from 15 to 30 per cent. No mention is made of possibilities beyond these numbers, and one is left but the one conclusion, that from 4 to 7 horse-power must be furnished to the compressor in order to produce a net yield of 1 horsepower in water pumped.

One hundred gallons per minute, lifted 200 feet, require about 5 theoretical horsepower. Consulting the various tables at hand, it is found that the efficiencies range from 17 to 40 per cent., the pressures from 110 to 20 pounds, the quantities of free air from 225 to 130 cubic feet per minute, and the cylinder ratios from 1 to 5 to 1. It may also be noted that the pressures required for the same cylinder ratios vary 150 per cent. The pressures given are all receiver pressures, or pressures in the main air pipe, which fact is not mentioned, leaving one to draw the

conclusion that no matter what the pressure in the main is, it is only necessary to install a pump with large cylinder ratios and use low pressures.

The average pressures carried, in the main, correspond very nearly to the steam pressures formerly used for the same work, and ninety pounds gauge, independent of the altitude, seems to be the standard mining pressure. All tables and pumping data should be calculated from some such standard basis, with proper coefficients for variations for the standard pressure, and a table giving the proper cylinder ratios for the different heads, using standard pressures as a basis, would be more helpful to those who wish to consult tables for guidance.

There appear to be six general forms of compressed air pumps: First, displacement pumps for full pressure only; second, displacement pumps using expansion; third, direct-acting pumps for full pressure only; fourth, direct-acting pumps using expansion; fifth, air-lift pumps, simple and combined with displacement chambers; and sixth, pumps operated by independent motors.

In the first style of pump, the Merrill type, two chambers are employed, submerged in the water, the compressed air being admitted directly to the chambers and displacing the water, the chambers acting alternately. With such a pump an efficiency of about 22 per cent. has been claimed, which is better than most ordinary direct-acting pumps will do with cold air. One can readily see, however, that this style of pump exhausts its chambers into the atmosphere at full pressure and all the expansive work contained in the air is lost. This system compounded, however, can be made very efficient.

In pumps of the second class, exemplified by the Harris system, the air, after displacing and raising the water as above, instead of being at once exhausted into the atmosphere is allowed to do work in expanding against the compressor piston, and thus, practically speaking, all its expansive energy is saved; but the manufacturers admit the losses in leakage and friction to be about 15 per cent. This is a very interesting and efficient system, and may be justly entitled to an efficiency of from 60 to 70 per cent. It should prove a very desirable system for mine station pumping.

In the third system we have a type of direct-acting pumps which are generally given a mechanical efficiency of 65 per cent. and an actual efficiency of from 15 to 22 per cent. They use the air at full pressure only. If a pump uses full pressure only, it is evident that the more full pressure a compressor diagram shows, the greater will be the efficiency of the system; the lower the air pressure, the less the compression work and the greater the proportion of full pressure work; consequently the lower the pressure, the more efficient the system. This really refers to the compressor and not to the pump, for the pump works the same whether it receives air at ten pounds pressure from the compressor, or whether it has been expanded from a receiver having a higher pressure, provided the temperatures are constant. If we look for the best efficiencies from the direct-acting pumps we must put in an independent compressed air system and carry low pressure.

The general conclusions in operating direct-acting pumps are as follows:

First—The lower air pressure in the main, with the cylinders designed properly, the greater the efficiency, reaching as high as 30 per cent.

Second—The efficiency drops immediately if the air is expanded through the throttle into an air cylinder which requires less pressure than the main.

Third—At standard mining pressure of ninety pounds the efficiency is about 17 per cent., with properly designed cylinders, and probably drops as low as 12½ in the pumps where just one turn of the valve is open.

Fourth—Very little loss occurs in using pressures within 10 per cent. of the pressures in the main, which is ample to impart proper dynamic head to the pump. Compound compression will increase these efficiencies 15 per cent., and reheating will also increase the efficiencies in proportion to the ratios of the absolute temperatures.

Fifth—Compound, direct-acting pumps are very little understood. The general idea has been that if the expansion of air produces such low pressures that it frequently freezes the simple pump, it would be an unwise proposition to try full expansion in compound pumps; consequently compressed air users practically avoid multi-cylinder pumps.

To use compound pumps the air must be heated in some manner. This reheating can be done either with the water which is being pumped, or extraneous

heating before the initial cylinder, or extraneous heating before the compound cylinder, or extraneous heating before both cylinders. By reversing the idea of the intercooler in compression and passing the air from the initial cylinder of a compound pump through a series of coils around which the water that is being pumped circulates, the air will take on very nearly the temperature of the water, and it will be delivered to the second cylinder at practically the same temperature as the first, thus permitting a number of expansions to be used, and the efficiency of any ordinary compound pump may be made equal to from 37½ to 40 per cent. by this simple method of water reheating. In other words, almost double the water can be pumped for the same amount of air used in a simple pump.

Where extraneous heating is used before the initial cylinder and between the two cylinders, the efficiency in compound pumps may be made to vary from 30 to 72 per cent., a vastly greater efficiency than is generally thought possible.

The combination of displacement and air-lift pump can be obtained in the Wheeler pneumatic pump.

The Cummings, or the two-pipe system, is a very interesting one, consisting of compressing the air to a high pressure—about 200 pounds—and exhausting it back from the pump at 100 pounds. This may be made to give an efficiency of probably 50 per cent., and if reheated, possibly more.

Air-lift pumping, or the Pohlé system, as it is called, is a simple system, which consists in reducing the specific gravity of water in the pipe by admixture of air, so that the head of water on the outside of the pipe will push it out. Extensive experiments have been made with it in America and in Germany, and it may be assumed that the efficiency may reach as high as, say, 50 and 60 per cent.

Motor-operated pumps consist of pumps belted or geared or directly connected to all kinds of engines. There is no doubt that with Corliss engines coupled directly to pumps, and properly reheated and compounded, the efficiency will reach somewhere about 75 per cent.

In conclusion, the efficiencies following are suggested. The percentages given in the table there may be taken as fairly accurate in comparing the various kinds of pumps, and the relations between them will be properly expressed by these figures, even if the actual efficiencies, as determined by other observers, may be somewhat different.

In explanation of the following table, the writer would say that the figures are on the basis of a pressure in the air mains of ninety pounds gauge. By foot-gallons is meant the product of the number of gallons pumped and the feet elevation that the water is pumped. This I find to be the most convenient and reliable way to designate the duty of pumps, and the foot-gallons designated are the work of one cubic foot of free air compressed to ninety pounds gauge pressure.

90 Lbs. Air Pressure on Main.

	Kind of Pump.	Foot Gallons	Efficiency Simple Comp.	Efficiency Compound
1.	Direct-acting simple..........	135	19	20
2.	Direct acting simple 300 reheated........................	180	24	28
3.	Direct-acting compound, water reheated	232	32	37.5
4.	Direct-acting compound, 1 cyl. heated 300....................	280	40	46
5.	Direct-acting compound, 2 cyl. heated 300........	326	46	53
6.	Direct acting triple cyl. heated 300..........................	383	54	62
7.	Direct-acting triple cylinder heated 400.....................	444	63	72
8.	Plain displacement	175	22	25
9.	Wheeler displacement, 34 per cent. for 34 lbs. pressure......	..	..	..
10.	Multiple displacement.........	320	40	46
11.	Harris displacement......... ..	60 to	70	p. c.
12.	Merrill displacement...........	175	22	25
13.	Cummings system.....	35 to	70	p. c.
14.	Compound motor pumps.......	50 to	80	p. c.
15.	Direct-acting triple water-heated.	300	42	48
16.	Pohlé air lift, 30 to 60 per cent. heads less than 300 feet	...	..	..

The second column shows the efficiency of the system with ordinary single-stage compressors and the third column with compound compressors.

No. 1 is the plain, direct-acting pump, like a plain boiler-feed pump, and the table shows that one cubic foot of free air, compressed to ninety pounds gauge pressure, will perform 135 foot-gallons of work; that is to say, it will lift one gallon 135 feet, or ten gallons 13.5 feet, and so on.

No. 2 shows that the above pump will perform 180 foot-gallons of work if the air is heated to 300 degrees before entering the pump.

No. 3 shows that an ordinary direct-acting compound pump, using the water

that is being pumped to heat the air on its way from the high to the low-pressure cylinder, will perform 232 foot-gallons of work, giving thus almost double the efficiency of No. 1, and requiring no fire heating—simply a little more investment in the installation.

No. 4 is the same kind of pump as No. 3, heated by fire to 300 degrees between high and low-pressure cylinder instead of utilizing the heat of the water. It is more economical, but the utility is not so high.

No. 5 is same pump as Nos. 3 and 4, but is fire-heated to 300 degrees before and after the high-pressure cylinder.

No. 6 is a triple-cylinder pump heated before and after the high pressure and after the intermediate to 300 degrees, giving 383 foot-gallons.

No. 7 is same pump heated to 400 degrees, giving 444 foot-gallons, showing that the same air as in No. 1, giving 19 per cent., can be made to give 63 per cent. properly manipulated.

No. 8 is a plain displacement tank, showing that it is more economical than an ordinary direct-acting pump.

No. 9, the Wheeler displacement pump, which is an ordinary tank displacement and an air lift combined, gives 34 per cent. efficiency.

No. 10 is a multiple displacement proposition where the displacement tanks are arranged above one another at distances corresponding to the ratios of isothermal expansion, giving a calculated efficiency of 40 per cent.

No. 11, the Harris system, where, after displacement in a tank, the air is returned through the compressor to the other tank operating in harmony with the first, is the most economical way of handling water by compressed air that the writer has seen.

No. 12, the Merrill displacement system, is a plain displacement system of two tanks.

No. 13, the Cummings system, which is used in connection with direct-acting pumps, is a two-pipe or closed system, delivering air to the pump at about 200 pounds per square inch and exhausting back to the compressor at 100 pounds, the idea being to utilize, as far as possible, the full pressure part of the air card. The economy is quite high, from 35 to 70 per cent., depending on the pressures carried and the character of the pump.

No. 14, compound motor pumps, refers to pumps driven by a compound air motor where heat is used before and after the high-pressure cylinder, and economies as high as 80 per cent. may be realized.

No. 15. Triple expansion, direct-acting pumps may be made to perform 300 foot-gallons of work, or 2.25 times as much as the same air will do with an ordinary direct-acting pump, by simply heating the air between the high and intermediate cylinders with the water being pumped, which has usually a 60-degree F. temperature.

No. 16 represents the air lift pump, which has an efficiency of from 25 to 60 per cent., depending upon the conditions.
—Edward A. Rix, in *Cassier's Magazine.*

The Paxson-Warren Sand Blast System.

The sand blast process has been before the public for more than 30 years, but not until the last ten years has it come into use in the foundry. Although not yet universally used, the merits of the sand blast are fast being recognized, and quite a number of plants have been installed during the past two years. The improvements made in air compressors and the more general use of compressed air, have, in a large measure, been responsible for this. It is not until comparatively recently that there has been on the market an efficient American built sand blast machine. The machine itself should be strongly built, to stand rough usage of unskilled labor. As damp sand will clog up any sand blast, hand holes should be so located that the obstruction can be removed at once without much trouble. I have seen with the use of the double shell sand blast fully an hour required to remove some damp sand. The machine had to be disconnected and hung up by a hoist so that the sand could come out through the top.

With the improved sand blast machine all this trouble is obviated. It has a single shell, no inside hopper, all parts are accessible through hand holes and all parts liable to wear can be easily replaced. The valve at the top of the machine controls the air supply, the one at the bottom regulating the supply of sand. The sand is fed in through a valved opening in the top head, which is closed when the ma-

chine is in operation. To operate, turn on the air and direct the jet of sand and air against the casting to be cleaned. The air serves to give a high velocity to the sand, which does the work. A specially designed helmet is used to protect the face of the operator. The most wear comes on the hose and nozzle. For hose we use a

THE PAXSON-WARREN SAND BLAST.

grade specially made for us; it is practically pure Para rubber, and will last, with constant use, from six months to one year. Length of hose may be used up to 50 feet, 12-foot lengths being long enough for most requirements. It has been found that hard iron tips and nozzles give the best satisfaction.

POINTS TO BE CONSIDERED.

An important point not to be overlooked is the quality of sand which should be used in these machines. It should be hard and tough and not too fine, and thoroughly dried and cooled before using, so that it will not steam and clog up the machine. Care should be taken not to overheat the sand, for this will cause it to break up, and a good deal of its efficiency is destroyed. To avoid trouble, it is necessary to have a good air compressor. The idea that because only a low pressure is used any old machine will do is a wrong one. As there are a number of first-class machines on the market, it is not necessary to mention any particular make. The compressor selected should have a confined suction, so that cold air can be supplied to it and thus avoid taking in more moisture than necessary. It is a well-known fact that cold air carries less moisture in suspension than hot air. The receiver should be located near the sand blast in order to trap out any moisture that may condense in the pipe. Either a belt or steam driven compressor may be used, as best suits the power conditions of the plant where it is installed. Where there is ample engine power available it is best to use a belt driven compressor, because a large engine uses steam more economically than a small steam driven compressor. The best place to locate the air compressor is in or near the engine room, so that the engineer can take care of it. With the proper size of pipe air can be conducted a long distance with very little loss in pressure. The number of cubic feet of free air required per minute will vary according to the opening in the nozzle and the pressure required to do the work. For brass castings 10 pounds pressure is sufficient; on gray iron castings 15 to 20 pounds is generally used; and for steel castings 25 to 30 pounds is required. Experience has proved that a large amount of air at a low pressure will do more work than a small amount at a high pressure.

The sizes of openings in the nozzles commonly used are 3/8, 1/2, 5/8, 3/4 and 7/8 inch. Many of the compressor catalogues give the amount of air that will be discharged through different sized orifices at certain pressures. As the sand takes up some room, it is obvious that the figures given will be ample for this service.

SPECIAL COMPRESSOR RECOMMENDED.

It quite frequently happens that an establishment having a high pressure air service already installed will consider the advisability of putting in a sand blast plant. One of the first questions arising is whether the high pressure air can be reduced. While this can be done it is not economical. Take, for example, a sand blast for cleaning gray iron castings, us-

ing air at 20 pounds pressure, through ½-inch nozzle, the amount of free air required would be about 120 cubic feet per minute. To compress this amount to 20 pounds requires about 9 horse-power. To compress the same quantity to 80 pounds would take about 23 horse-power. As there is no power or advantage gained by reducing, there would be a loss of about 14 horse-power, and the total loss for a year would amount to nearly the cost of a special compressor for this service.

In the preceding part of this paper the sand blast proper and the compressor for furnishing the blast have been described. As the sand blast makes a large amount of dust it is customary in most cases to have it installed in a room by itself, of sufficient size and conveniently arranged to handle the work. In all cases I would strongly advise using an exhaust fan to take away the dust. The size of fan will vary according to the size of the room; size of sand blast and amount of dust to be exhausted. It is better policy to install a large fan and run it a medium speed than to run a smaller fan at a high speed to do the same work. While the first cost may be a little more, the difference will easily be made up by the horse-power saved. Where it is objectionable to exhaust the dust out doors it becomes necessary to install a washer that sprays the dust as it is drawn through, so that the exhausted air is practically clean. The dust settles to the bottom of the washer as mud, and occasionally has to be shoveled out.

USING SAND OVER AND OVER.

Where the sand blast is used on a large scale it is an advantage to have an arrangement for preparing sand so that it can be used over and over. In this case a hopper is located in the center of the room, or to one side, and covered with a grating. The hopper discharges into an elevator boot, from which the sand is elevated and fed into a revolving screen, where the fine sand is screened out into a dust box and the tailings fall into the sand box, which is above the sand blast. From the sand box the sand is fed back into the sand blast as required. With this scheme the fine sand does not get into the washer or fan, consequently the washer does not have to be cleaned out as often. The belt elevator is a positive device, and when it is properly fed gives good satisfaction. As the conditions in any two plants are never exactly alike it requires considerable thought to get the best arrangement and one that will give the best satisfaction.

For cleaning large amounts of small castings a sand blast tumbling barrel is used to advantage. Capacities of these barrels vary from 5 to 10 tons per day. The barrel, mounted on rollers, is filled less than half full and caused to revolve very slowly, say three or four revolutions per minute. The sand blast jets are introduced through the ends of the barrel, and as the barrel revolves each casting comes in contact with the blast. The time required to clean one charge varies from 20 to 30 minutes. The advantage of this method is that the castings are thoroughly cleaned and the sharp corners preserved. The barrel itself is covered with a sheet iron casing, which is connected to an exhaust fan and washer, if necessary.

In comparing the sand blast process with other methods of cleaning it is unfair to make comparisons with methods where the castings are only half cleaned. In the bathtub business the sand blast is almost an absolute necessity on account of the labor saved, and because it is the best way to prepare tubs for enameling. On castings to be machined there is a great saving on the tools in the machine shop. The sand blasted casting takes paint better and has a more finished appearance than a casting cleaned in any other way. In most cases, where the sand blast is properly installed, it should pay for itself in two or three years. The sand blast is not confined to the foundry alone, but is extensively used for removing scale and rust from sheet iron and structural work, for cleaning brazed joints and for cutting and cleaning marble and other stones; for cleaning pieces to be galvanized it is of great service, as it does away with the possibility of the acid eating into the metal and impairing its strength.

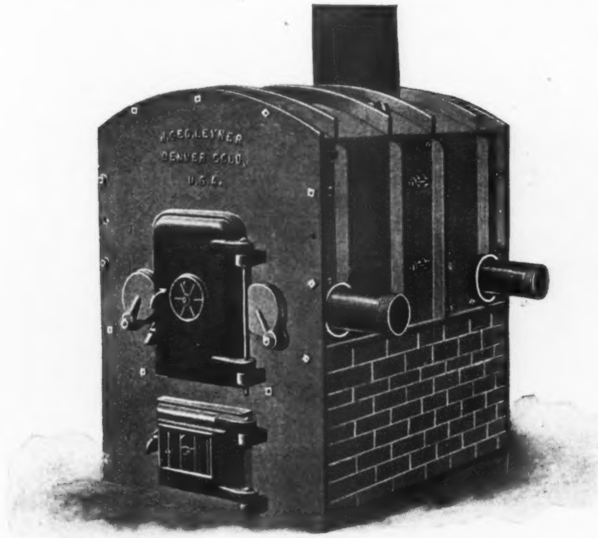
Compressed Air Reheating.

The advantages to be gained by the heating of compressed air before delivery to the engines are not sufficiently well understood by mine operators. It is true

that there are difficulties to be overcome which, until they are solved, militate against the use of reheaters underground. The chief drawback is due to the fumes and gases given off by the reheater; this problem should, however, be capable of ready solution and in view of the enormous gains to be made it is well worth attacking.

In brief the system consists in passing the air, compressed say to seventy or eighty pounds per square inch, through a coil of pipes heated by means of gas, petroleum or coke. The air is thus raised from a temperature of about 60° to 350° F. Under the best conditions the mechanical efficiency is exceedingly high, as much as seventy per cent. having been obtained under test conditions. This means that one-fifth of one pound of coal has developed in the reheater one horsepower per hour as against from two and one-half to five pounds of coal at the compressor; it converts a notoriously wasteful method of obtaining power into a much more economical force. Finally the machines using the hot air are much more efficient than when using cold air.

The most thorough study of the effect of reheating compressed air for power purposes has been made in the famous compressor plant in Paris, although in the California mines much attention has been given to it. About 1888 a gigantic air compressor plant was erected in Paris for the purpose of delivering cheap power to small factories, private houses and for such general purposes as power is needed in large cities. The city of Paris was dotted with stations for compressing air, one being laid out with a capacity of 24,000 horsepower, although we are not aware that this amount of power was ever generated. The system was designed by M. Popp, the famous French engineer. At first the air was used in the condition in



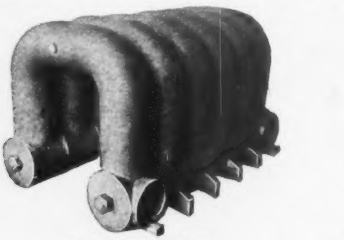
LEYNER REHEATING STOVE.

which it left the stations, but with very unsatisfactory commercial results. Indeed it appeared, at one time, as if the system would have to be condemned. In this dilemma Popp commenced experimenting with small and crude reheaters made of coils of pipe and heated by coke or city gas. The result was a saving of nearly forty per cent. in the consumption of compressed air and the enormous outlay of capital was saved, partially at all events.

The results obtained by the reheaters will be of interest to all those who use compressed air, and in view of the very

great advantages to be gained it is well worth the while of mine operators to experiment along the same lines, especially if their present compressor power is too small for the work to be done in the mine. The effect of reheating is not only to increase the efficiency of the compressor system, but also allows it to do more work.

At Paris, when the Popp system of air compression was first adopted, the consumption of air was enormous. Rotary engines of one horsepower capacity and working expansively, consumed no less than 1,469 cubic feet of cold air per brake horsepower per hour, but when the air was heated to only 122° F. the engine only consumed 960 cubic feet of air. A two-horsepower engine used 1,059 cubic feet of cold air and 847 cubic feet heated air per brake-horsepower. It was found, finally, that the air should be heated to



COILS FOR STOVE.

about 350° F., and the consumption of air was then reduced to about ten cubic feet free air per horsepower per minute as against fifteen to twenty-five cubic feet for cold air. The amount of fuel required was trifling and it was demonstrated that about one-half pound of coal in the reheater gave one horsepower of useful work at the engines. It was further found that a heating surface of one square foot was needed for every 750 cubic feet of free air heated per hour. The size of the heater required is therefore not very large. The cheapness, the efficiency and the simplicity of the reheater stoves is so obvious that it is somewhat surprising that they have not been adapted to mining work. Of course the air, after leaving the stove, should be carried in covered pipes to the pumps, drills or other machinery which is being operated. Ordinary steam pipe covering answers admirably for protecting pipes carrying hot compressed air.

Herewith is shown the heating stove designed by J. G. Leyner, the Denver manufacturer of air compressors and drills. It appears admirably adapted to the purposes for which it is designed.—A. W. WARWICK, in the *Mining Reporter*.

Air Lift Pump on the London Central Railway.

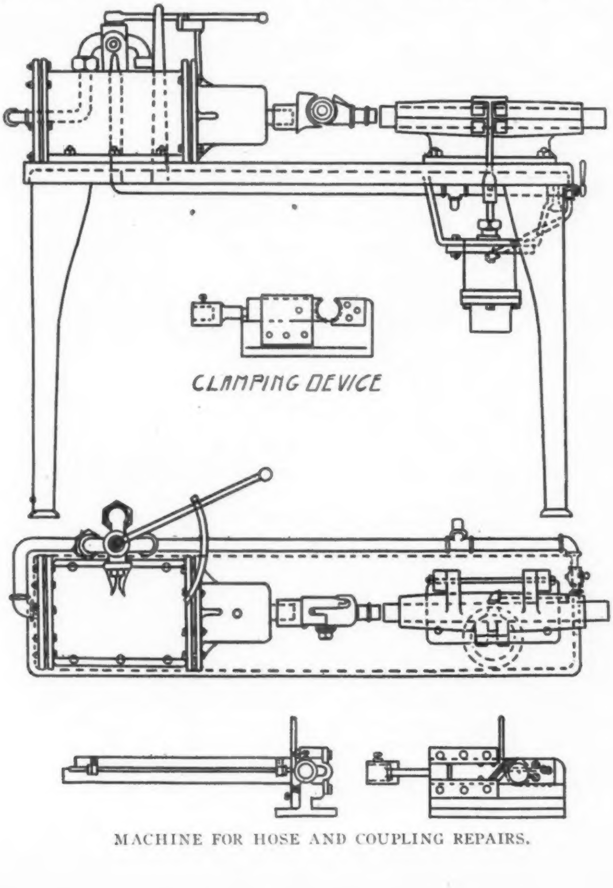
In a recent issue of the *Financier and Bullionist* there is an article describing a new air-lift pump which has been installed at the power stations of the Central London Railway and at Ilford. It is well known that the efficiency of an ordinary deep-well pump is only about 40 or 50 per cent. after it has been working for some time, while the efficiency of an ordinary air pump is 25 per cent. at the best. In the event of any grit getting in the valve of a deep-well pump the result is anything but pleasing. The pump has to be stopped for a period of several days, sometimes weeks, and the slightest breakdown of any detail in connection with the pump occasions a long delay and a consequent waste of a large amount of time and money. The risk of breakdown is almost eliminated in the air-lift pump, and the simplicity of the system is a distinct point in its favor. One power house can supply the necessary power for any number of pumps, and when all expenses entailed by repairs, etc., are taken into account, it is not at all certain that the efficiency of the deep-well is better than that of the air-lift pump—at any rate, from a financial point of view. This only applies to an air-lift pump with an efficiency of about 25 per cent., but by the invention of Mr. Joseph Price, of the firm of Messrs. Le Grand and Sutcliff, it is claimed that this can be increased by 40 per cent. With the ordinary air-lift pump a certain amount of water is forced up a tube of uniform bore by compressed air, which, as it rises, expands and parts with a good deal of its energy in giving momentum to the column of water above it. This, of course, causes the water at the top of the tube to move considerably faster than that at the bottom. Mr. Price has departed from the rule of making the tube of uniform bore, and has made the rising main to taper. As the air rises with the water it still expands, but as the tube is greater in diameter it can expand later-

ally, thus leaving the actual height of the column the same as when it entered the tube at the bottom. No additional momentum is given to the water, and it leaves the rising main at precisely the same rate as it entered. This pump should be of considerable service to central station engineers and to those engaged in mining work, and in any case where a continuous supply is needed.

Air Hose Repairing.

Many railroad shops have in use some form of machine adapted to assist in the repair of air brake hose, and a great saving is thereby effected on account of the large individual expense item caused by necessary hose renewals. A machine is here illustrated which has been in use on the Southern Pacific for several years, and which performs the operations necessary in making over old hose.

The machine consists of a flat lathe bed, upon which is mounted a horizontal air cylinder, and provision is made for the placing of three attachments upon the bed by the attendant. In repairing, the first operation consists in cutting off the old hose squarely, and this is accomplished by placing in position the cutter, shown detached, into which the hose is placed. The air is turned on and the knife shears off a length, which may be determined by means of a supporting scale extending to the rear. After a number of hose are cut the proper length, the cutter is removed and a clamping device, shown in position,



MACHINE FOR HOSE AND COUPLING REPAIRS.

is applied. The hose is laid in this clamp and held by the use of air pressure in the vertical cylinder underneath the machine bed. A dummy connection on the main air cylinder piston rod holds the hose connection, and upon the application of air pressure it is forced into place in the hose end. This operation completed for the lot, the clamping device shown detached is placed in position and the clamps applied by power.

Although it is apparent that some changing is necessary, yet the alterations, consisting in simply lifting off the attachment in use and setting the desired one upon the form, are accomplished quickly. In running through a large number of hose, the whole may be renewed at a great saving of time over other methods and with a better grade of workmanship. This machine is manufactured by the J. D. Connell Iron Works, New Orleans, La., who hold patents covering the same. —*Railway Age.*

Rand Belt and Motor-Driven Compressors.

The accompanying illustration shows a new type of air compressor designed for machine shops, foundries, and other industrial establishments where little attention can be given to a compressor and where compactness, simplicity and strength in design are appreciated. The compressor requires a small floor space so that it can be set up "out of the way" and is driven by belt direct from a main shaft or countershaft, or, as shown in the illustration, it is conveniently driven by a gas engine or electric motor. As a direct connected gear driven compressor for portable or stationary use, the design permits of the most compact arrangement. Two machines may be operated by the one motor, if circumstances require it.

Each compressor has two single acting vertical cylinders, fitted with extra long trunk pistons, which act as guides for the lower ends of the connecting rods. This does away with stuffing-boxes and crossheads, and reduces the height of the machine as well as the number of bearings. The cranks are set opposite to each other so that one piston and one connecting rod are moving downward while the opposite piston and connecting rod are moving upward. One side thus perfectly counterbalances the other.

The belt wheel is placed between the two main bearings and is made unusually large, with broad face to give ample belt power without straining the belt. Its rim is made very heavy so that it acts as a balance wheel. In the direct motor-driven compressor the belt wheel is replaced by a heavy gear wheel as shown.

For pressures above 25 pounds the cylinders are water-jacketed and are cast in one piece with the frame, insuring rigidity. They are bored on a special machine and finished with a reamer. The main borings are also bored out at the same time. The main bearings are fitted with removable shells made of hard babbitt metal, which when worn out can be easily replaced at slight expense, thus restoring the original correct alignment of the machine.

Both crank pins and crosshead pins are made of special steel and are hardened and ground. The connecting rod is of malleable iron, and there is no strain on it except that of compression, as all work is done on the outward stroke. Both ends of the connecting rod are bored out and fitted with hard bronze bushings, which can be easily and cheaply renewed when they are worn out.

The inlet and outlet valves are of the poppet type, fitted with light springs, and work vertically. On account of their position at the bottom of the cylinder they are well lubricated, and also on account of their vertical position there is no tendency to wear down out of line with their seats. They are made from drop forgings, are light and practically indestructible, do not hammer the seats and are prevented from getting into the air cylinder (in case of breakage) by sheet steel guards.

The inlet valves for both cylinders take air from a common passage, which is tapped to receive a pipe leading out doors or to some place where air at a lower temperature may be obtained. The outlet valves on both cylinders discharge into a common passage, which is tapped to receive a pipe connecting with the air receiver.

The base of the machine is high enough so that the air heads can be readily removed. Any valve can be removed without disturbing the air head, by simply unscrewing the cap over the particular valve. The main bearings, crank pins and crosshead pins are of unusually generous proportions and these bearings will run for long periods without readjustment. The pistons are packed with cast-iron

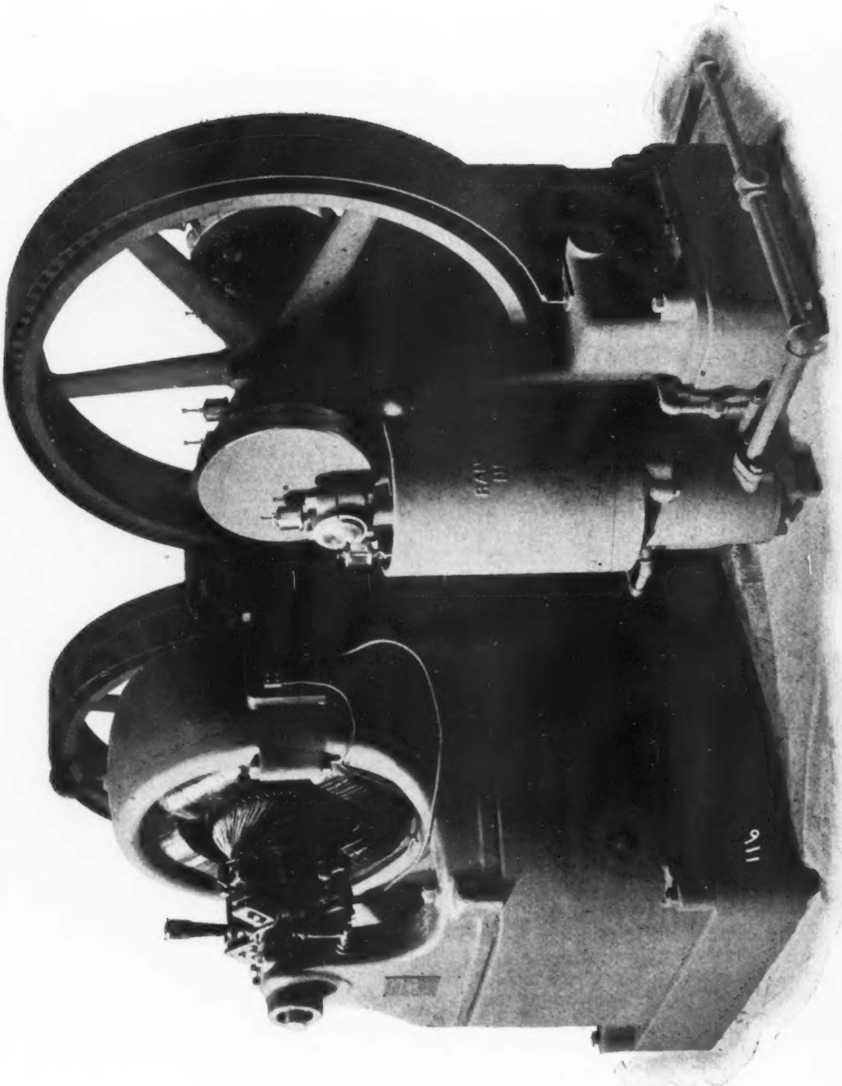


FIG. I.—DIRECT MOTOR-DRIVEN AIR COMPRESSOR.

snap rings of approved construction. Each compressor is fitted with an automatic regulating valve attached to the common inlet pipe, which throws off the load without stopping the machine, when the pressure reaches a predetermined limit, and again throws on the load as soon as the pressure is lowered.

Efficient means are provided for lubricating the cylinders and all bearings. At the top of the cylinders there is a metal projection which catches the drip from the main bearings and crank pins, and any oil which may work out from the cylinders. These compressors are designed for air pressures up to 150 pounds per square inch, and range in capacity from 16 cubic feet to 500 cubic feet of free air per minute.—*Iron Trade Review.*

Compressed Air versus Gas and Steam.

Compressed air has become such a factor in the manufactures throughout the United States that the scientists and skilled mechanics have been called upon to prove that it is a far safer power than either steam or gas. When it is considered that compressed air is put to an almost limitless number of uses it seems remarkable that so few accidents occur. Every case reported so far in the technical journals is credited to carelessness or ignorance on the part of the workman.

Compressed air installations are used with pressures up to 3,000 pounds to the square inch, not only in every mine of magnitude, but in all tunnel work, quarries, shipbuilding, submarine work, and for refrigerating purposes. Its greatest range really is in all railroad and manufacturing lines.

Nearly every railroad, machine, erecting and boiler shop and foundry of any size has its own compressor plant. From all of these varied sources comparatively few accidents have been reported. As a means of safety many of the powder magazines throughout the country are using compressed air as a motive power, to the exclusion of steam and electricity. Railroad trains, both freight and passenger, are equipped with air compressors and storage tanks, and on the latter the power is used for as many as eight different purposes, such as the braking of trains, ringing bells, opening fire doors, shaking grates, sanding the rails, lifting tender water scoops, raising water in passenger coaches and operating fans for ventilation.

The reason compressed air is a safe power is the fact that it has no reserve force, as in the case of steam boiler explosions. The failures that have occurred in the use of compressed air can, in nearly every instance, be traced back to the ignition of oil or some inflammable substance which is used with the air. Low-test lubricating oil, for example, fed to the air cylinders, may meet with a temperature greater than that of its flashing point. In putting oil into the cylinders and surplus that may reach the cylinders is forced out through the delivery valves into the air pipes and receivers. The products of decomposition of a large quantity of oil in the receiver would, with the air, form an explosive mixture.

Air in itself is a perfectly safe fluid, and only requires a vessel strong enough to hold it. In this respect the problem is not a serious one, as the factor of safety in the case of air may be less than for steam, water or gas, as it does not corrode the vessel, its temperature is not changed, and it causes no internal destruction. —*Modern Machinery.*

Arnold's Electro-Pneumatic Motor Car.

At the convention of the American Institute of Electrical Engineers, at Great Barrington, June 20, Mr. Bion J. Arnold, after reading his paper on "Electric Power for Heavy Railroad Service," gave a brief description of a system which he has designed for utilizing compressed air, stored on each car, in the propulsion of electric cars. He said that he was constructing 20 miles of road* to be worked by this system; and the necessary trucks and motors are being built. Mr. Arnold believes that it will be necessary ultimately to abandon the direct current motor for heavy and long distance service. The main points of his description are as follows:

*The road to which Mr. Arnold refers is the Lansing, St. Johns & St. Louis. The line begins at Lansing, Mich., and runs northward to St. Johns on the Grand Trunk (D., G. H. & M.), and thence to St. Louis on the Pere Marquette. It was briefly described in the *Railroad Gazette* of Feb. 21 last, page 134. The length of the entire projected line is 60 miles. The part of the line on which the track is finished is that between Lansing and St. Johns. We understand that this portion has been in operation some time, steam locomotives being used.

1. A single phase or multiphase motor, mounted directly upon the car, designed for the average power required by the car, and running continuously at a constant speed and a constant load, and, therefore, at maximum efficiency.

2. Instead of stopping and starting this motor and dissipating the energy through resistances, as is customary with all other systems, I control the speed of the car by retarding or accelerating the motor, by means of compressed air, in such a manner that I save a portion of the energy which is ordinarily dissipated through resistances, and store it to assist in starting the car, helping over grades, for use in switching purposes, and for the operation of the brakes.

3. By this method of control I secure an infinite number of speeds from zero to the maximum speed of the car, which may or may not be at the synchronous speed of the motor, for with the air controlling mechanism at work compressing, the speeds below synchronism are maintained, and by reversing the direction of the air through the controller, speeds above synchronism may be attained for reasonable distances. This feature gives to the alternating current motor the element absolutely essential for practical railway work, for it permits a car or train to ascend a grade at any speed with the motor working at its maximum efficiency, and imparting its full power to the car. When descending the grade the motor may utilize its full power drawn from the line in compressing air, or it may be used to compress air with the stored energy of the train, thereby acting as a brake.

4. By virtue of the air storage feature each car becomes an independent unit and capable, in case of loss of current from the line, of running a reasonable distance without contact with the working conductor, and this without the aid of storage batteries. This feature will be valuable in switching and in crowded cities.

5. Since a single-phase motor can be used the motors can be supplied with current from a single overhead wire or third rail, and with a single rail return circuit, thus permitting the overhead constructions, or third-rail construction, to conform to the standard of to-day, except that a much higher working voltage can be used, provided the insulation is taken care of. In steam railway work the use of only one of the track rails will be required for the return circuit, thus leaving the other rail for the use of the signal system.

6. The current will be taken from the working conductor at any voltage up to the limit of the insulation, and in case this voltage is high (I am building my line for 15,000 volts), a static transformer will be carried upon each car and the pressure reduced from the line voltage to the voltage of the motor, which, in the case under construction, is designed for 200 volts. Where it is unnecessary to utilize so high a line pressure the motor may be designed for the working voltage and the current fed directly from the working conductor into the motor, thus eliminating the static transformer. When a high voltage working conductor and static transformer are used, and it is thought advisable to use a working conductor through cities or towns this working conductor will be supplied with energy through a stationary transformer at each city limit.

7. By virtue of the speed of the motor and its constant load, either when the car is in motion or when it is standing still and motor compressing air, the variable load now customary in electric railway power plants is eliminated, and the power station works at practically a constant load, thereby eliminating a large part of the investment at present requisite in power station and line construction. Furthermore, by virtue of the air storage feature, each car, in the particular apparatus I have designed, is capable at any time when current is on the working conductor of delivering to the car wheels a much greater torque in proportion to the capacity of the motor than is possible with any electrical system known to-day. —*Railway Gazette.*

Removing Sand from Wells by Compressed Air.

When sand is to be removed from wells it has been suggested to blow out the wells by compressed air, the method being to pump up a high pressure in the receiver and to discharge it through a small pipe put

down the well. The idea of this was not only to blow the sand out of the well by stirring it up and carrying it off by the large flow of water due to the action of the air lift, but also to make such action sufficiently violent to knock any rust off the perforations. Particularly on this last account it is thought that this would be superior to the system of using the sand pump.

This was tried in three different artesian wells. In none of these instances was any appreciable benefit accomplished. But this was not due to the fault of the system, but simply because the water had fallen in these wells due to dry years and the interference of other artesian wells. In the first well experimented with the water stood about two feet below the ground. This was blown out by compressed air. A pressure of 300 pounds was pumped up in a receiver of about thirty-five cubic feet capacity and discharged through a one-inch pipe, the open end of which was near the bottom of the well, about 550 feet deep. The discharge shot a stream of water about forty feet into the air. It looked for the time being like a young geyser. After the discharge the water in the well went away down and gradually came back again. Then the air compressor was allowed to discharge steadily into the pipe and to pump from the well as an air lift. The result of this was to bring up a steady stream of water containing much sand and large pieces of rust. Several runs of an hour or so were made on this well, but at the end of that time the water stood just where it had before the tests were begun.

The next well on which this was tried was about a mile away on lower ground, giving a flow of 17.9 miners inches. This well was 399 feet deep and of six-inch casing. A one-inch pipe was run within about six feet of the bottom of the well, 300 pounds pressure was pumped up in the receiver and the well blown out three times, after each discharge letting the compressor run into the pipe down the well for about twenty minutes. A measurement of the sand blown out showed that 37,500 cubic inches, equivalent to a volume of 110 feet of six-inch casing had been removed. This lowered the well bottom only about three feet, showing that it was an open bottom well. After these runs the measurement of the flow of the well was 18.9 miners inches, about 5 per cent. increase. Then one-half of the pipe in the well was taken out, leaving the end 200 feet down under the water. The receiver was again pumped up and discharged. The result of this discharge of the receiver was that the water ceased flowing entirely and stood about ten feet down in the well, showing that the bottom had filled up with sand. Keeping the pipe at the same 200-foot level the compressor was run for about half an hour, pumping steadily into the well. At the end of that time the well had resumed the same flow which it had before making this last test. The sand removed in this last blow and run was equivalent to forty-four feet of six-inch casing—the size of the well—the depth of the well at the end being 402 feet. The hydrostatic head of this well was only twenty-eight inches above the level of discharge, so that had the pressure in the ground fallen twenty-eight inches the well would have ceased to flow. The stream of water which shot up from this well on discharging the compressor went far above the derrick, about seventy-five feet in the air. It came out with a loud roar.

The next well tested had only a small flow of about half an inch of water. The well was about 575 feet deep. A ¾-inch air line was run down near the bottom of the well and 450 pounds pressure pumped up in the receiver and discharged. The illustration shows a view of the water shooting out of the well as the discharge was subsiding. After the discharge the water went away down in the well, and seemed to come up spasmodically from the action of the compressed air, every once in a while sinking far down. On taking soundings the well had filled up about 200 feet. By continuous running of the air the sand was lowered about 130 feet, but it was impossible to lower it still further, as it seemed to run in as fast as it was pumped out. The sand was exceedingly fine quicksand. The last seventy feet of sand removed had to be taken out by a sand pump. Subsequent inquiry developed the fact that a string of tools had been lost in the well, and that gunpowder had been used in it and had probably blown a hole in the bottom of the casing. It was either through this or else through the perforations that this fine sand came in as fast as it could be taken out by the air lift, the flow of water into

the well when pumped by the air lift being sufficiently great to carry this sand in with it.

The conclusion of these experiments is that for obtaining good results in cleaning wells by the air lift, first, that the well should be capable of furnishing a sufficient supply of water to carry off the sand; second, that it is sometimes better not to use the discharge from the receiver, but to pump the well steadily. A discharge from a receiver will cause a sudden diminution of pressure on the inside of the casing. Should the casing be old and the water supply from the well small this may be sufficiently violent to collapse the casing. Third, it is not always necessary to put the end of the air pipe at the bottom of the well. When the receiver was discharged into this well those looking on were astonished to see a large tin can, a bottle and a few fence posts come sailing out of the well on the top of the water spout. The meanest man in the world is the fellow who puts things down wells.—Abstract from *Power, Electricity and Gas.*

Plate by The Half Tone Co., S. F.

BLOWING OUT A WELL BY COMPRESSED AIR EXPLOSIONS.

Reversible Pneumatic Drill.

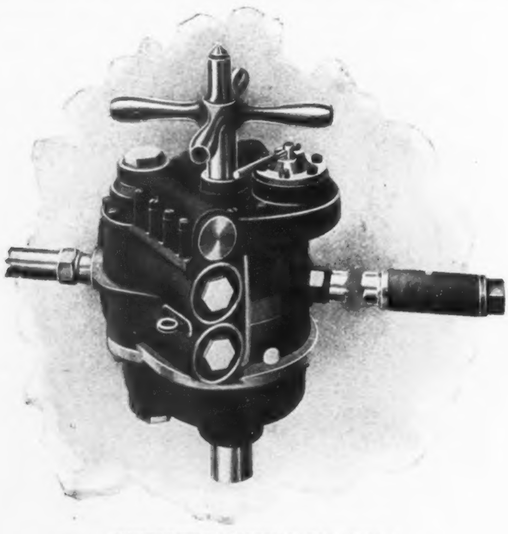
We illustrate herewith a new reversible drill of the "Little Giant" type, recently developed and put on the market by the Chicago Pneumatic Tool Company.

This machine was primarily designed to meet the want of customers who required a drill for general use, but whose work is not sufficiently specialized to warrant the purchase of any one of the "Little Giant" exclusive reaming and tapping machines.

The motor is of the same general construction as all of the now well-known and time-tried "Little Giant" drills, the distinguishing feature of which are four single-acting pistons coupled to one crank-shaft at an angle of 90 degrees. Each piston of each pair traveling in opposite directions at all time insuring a well-balanced and durable engine. All moving parts are in an oil-tight case and each pair of cylinders controlled by one balanced piston slide-valve. These features are fully covered by United States and foreign patents, and are found in no other pneumatic drill. To this has been added a simple reverse valve of same construction as in Nos. 11 and 12 machines, but so situated that it does not interfere with the feed screw when the machine is used as a simple drilling machine.

The controlling lever may be removed from motor when not required as reversible machine. It can then be controlled with the ordinary throttle, which is situated at side of machine as in the plain drills.

The reverse valve can be used as a throttle-valve, however, when very rapid and accurate reverse motion is required, as would be the case when motor was used in connection with machine for setting locomotive slide-valves, or tapping to a given point, or to bottom, and various other applications, which will readily suggest themselves to the mechanic requiring a machine of this kind.



REVERSIBLE PNEUMATIC DRILL.

The motor is made in the following sizes:

No. 00, same size as plain No. 0 Drill.
No. 10, same size as plain No. 1 Drill.
No. 22, same size as plain No. 2 Drill.

Like parts of these drills are interchangeable with the plain drill of same size, features which will be appreciated by the trade, as it avoids complication of parts.

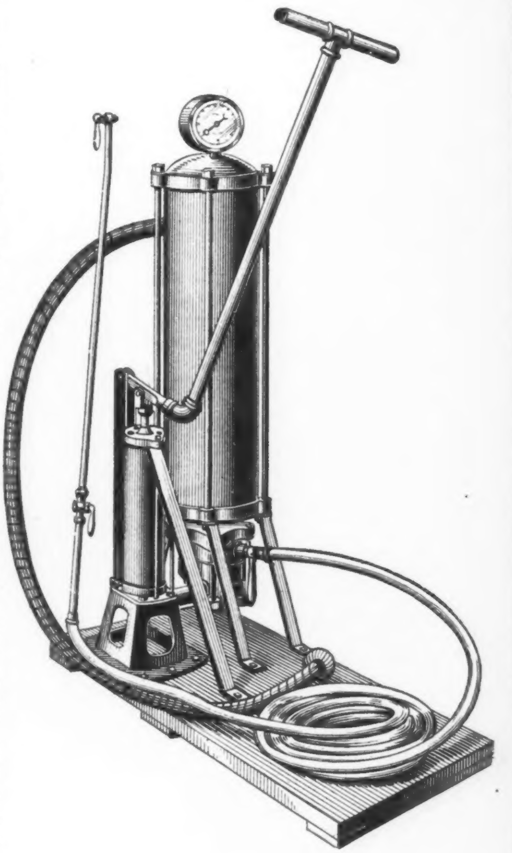
Some of the improvements that will be appreciated by mechanics who have used

these drills are as follows: All bearings are furnished with removable bushings; the crank journals have been increased by 50 per cent.; the crank pinion is now shrowded on both ends (formerly on one end only)—this will prevent teeth from breaking; the upper and lower bearings for crank shafts are bronze; sleeves of ball of ball and socket form easily removed–no screws required to hold them in place, which form of bearing insures perfect alignment always and consequent increase in speed and power; hardened steel eccentric straps connect valves to crank-shaft in place of bronze used formerly; oil plugs have been dispensed with; oil is poured in through handle, and, as it is impossible to use drill without this handle, and nothing but the handle will fit the hole, it will surely be replaced even by the most careless workman, and this insures long life to working parts; a leather-packed stuffing-box is supplied to keep oil from escaping; every moving part is hardened and ground to fit.

Pneumatic Coating Machine.

Mr. F. E. Hook, Hudson, Mich., is the originator of the Pneumatic Coating Machine (which we illustrate herewith), the principle of which is the compressing of the air and the liquid into the receptacle while the compressed air discharges the liquid through the hose and a special nozzle in the form of a misty spray. The machine is arranged with a contained air pump, by means of which one is enabled to obtain 40 pounds of air pressure in the receptacle in less than three minutes. This pressure is increased by the pumping in of the liquid to 150 pounds, and when this pressure is in the machine it will spray out automatically, without anyone operating the handle, for nearly twelve minutes. The valve and valve chamber are so arranged that the compressed air passes through the liquid to the top of the receptacle at all times, so that it not only keeps the liquid thoroughly mixed, but the air, on compressing down on the liquid, forces it out through the discharge hose, as before stated.

Where three men are using the discharge it is necessary to have an extra man at the pump, as the machine would not have capacity enough to supply the liquid fast enough for three men without the working of the pump. The 40 pounds of air which is first put into the receptacle is not discharged out again, but is put



HOOK PAINT SPRAYER.

there simply for the purpose of keeping the liquid agitated, and forms the means of discharging the liquid. In this respect the machine is radically different from the air compressor machines, which use the compressed air to form the spray.

Modern Water Supply Stations for Locomotives.*

Compressed air is used for raising water, and that there is a particular field for this form of pumping does not need proof. The requirements for such a system are an air compressor, and, of course, some means of driving it; frequently the compressor is run by a gasoline engine, and the two may be made very compact.

Compressed air gives a very convenient means of raising water from deep-driven wells, because the operating machinery is all above ground and the pipes, if they are found out of order, are easily and quickly replaced; another condition which justifies the use of compressed air is the necessity of using a number of wells to provide the necessary quantity of water, allowing the water from the various wells to flow either to the place where needed, or to flow to the suction of force pumps. The air-lift will not deliver the water horizontally to any great distance, so that when the lift, or well, is at a greater distance than 40 feet from the place where the water is to be used it is generally necessary to raise the water perpendicularly at the well to such a height that it will be delivered by gravitation to the place desired, or to provide other means for the horizontal delivery. The construction of such wells is probably so thoroughly understood that only a few words are necessary here, that there may be left no possibility of misinterpreting to what reference is made. There is the pipe projecting into the well, through which the water is to be raised, and there is another pipe, or passage, through which compressed air may be delivered to a place near the bottom of the well, where there is connection between the air passage and the water-delivery pipe.

This means of pumping can be used to advantage also when it is desired to locate the pumping machinery at some distance from the well. This condition may arise when it is difficult to get the machinery or the fuel for operating it sufficiently close to the well; or when it is possible, by locating the machinery at some distance from the well, to keep the attendant busy at other work, when his services are not required all the time for pumping water. Also compressed air may be available for other service at the place where required, and in the use of it for raising water a considerable economy may be shown.

For example the details of the water system at the Denver shops of the Colorado & Southern Railway may be taken. In this plant there are two artesian wells, 700 feet deep, in which the water rises to within 160 feet of the top, and twenty surface wells, 27 feet deep, in which the water rises to within 5 feet of the top. The water from the artesian wells is used for boiler purposes, and the surface water is used for washing and for other similar purposes.

Information concerning the proper proportioning of air-lifts has been the result of experience obtained by those who are engaged in making air compressors and in designing air-lifts, and the formulæ which have been deduced from experience are treasured highly and are not available for publication. The general practice is, however, to make the relation of the submersion to the lift from 4 to 3, to 3 to 2. This is the "working" submergence as distinguished from the height at which the water stands in the well before pumping is begun; generally the water level in the well falls as soon as pumping is begun. If a lower percentage of submergence is used the cost of operation is increased. The weight of the column of water above the air inlet is readily calculated, and this will equal the pressure at which the air must be delivered to the point where the air and water are mixed. The starting pressure will be greater than the working pressure. The working gauge pressure in pounds per square inch, divided by the atmospheric pressure at the altitude of the well, will give a quotient to which, if unity is added, will give the number of volumes of free air required. The capacity of the well may be calculated by allowing 15 gallons per square inch of cross section of pipe per minute, or by taking the rate of flow in the discharge pipe at 5 feet per second. For heights of from 15 to 50 feet there will be required 2 to 3 cubic feet of air at atmospheric pressure per cubic foot of

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*Abstract of a paper by Mr. F. M. Whyte, Mechanical Engineer, N. Y. C. & H. R. R. R., read before American Master Mechanics' Association.

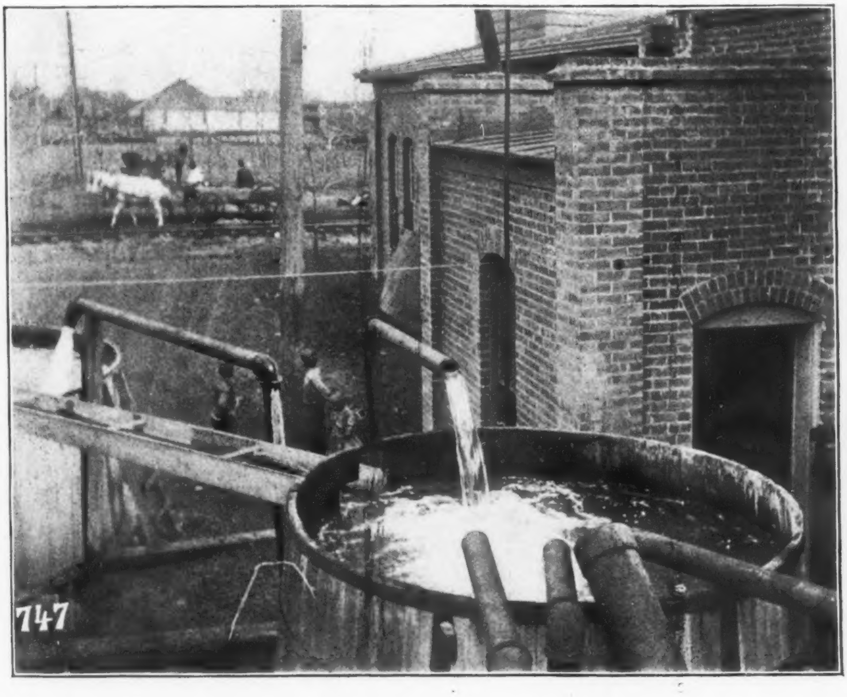
water delivered; for heights of from 50 to 100 feet it is considered best to provide 3 to 6 cubic feet of free air at atmospheric pressure for each cubic foot of water delivered. The efficiency of this system of pumping is about 50 per cent. maximum, and may be as low as 15 to 20 per cent.

The water is not raised usually by air pressure; the air mixes with water in the delivery pipe, making the weight of the column of water and air in the pipe less than the weight of the column of water outside of the pipe. Sufficient air must be mixed with the water to make the difference in weight of the column inside the delivery pipe and the one outside of it such that they balance each other when the column inside the pipe stands at a height slightly in excess of the height to which it is desired to raise the water. If more than the required amount of air is forced into the delivery pipe the cost of raising the water will be increased. The water may be forced to some height by increasing the air pressure, but the expense in so doing becomes excessive.

Western Air Lift Plant.

We present herewith an illustration of a Western air-lift plant, which affords another instance of the utility of this means of raising water from artesian or deep wells.

This plant lifts about 600,000 gallons of water every twenty-four hours, with a total vertical lift of from 360 to 370 feet. The air pressure is 125 pounds at the receiver, and the compressor is estimated to give about 115 horse power.



AIR LIFT PLANT. CAPACITY 600,000 GALLONS IN TWENTY-FOUR HOURS.

Electrical Engineers' Pocket-Book.

A hand book of useful data for electricians and electrical engineers by Electrician, Horatio A. Foster, M. A. I. E. E.; size containing 987 pages, leather bound; fully illustrated; published by D. Van Nostrand Co., New York. Price $5.00.

We take pleasure in calling the attention of the readers of COMPRESSED AIR to this work on electrical engineering, which is to the practical engineer what Trautwein and Kent are to the civil and mechanical engineer. The book is gotten out in hand-book style and is a cyclopedia of electrical data, which is needed by anyone dealing with the design, construction or use of electrical machinery.

The book has been prepared with the aid of a number of specialists and is unquestionably the most satisfactory collection of useful electrical data which has ever been published. The whole range of applied electricity is covered in a very practical way, and a number of subjects, regarding which it was almost impossible to obtain data without an extended examination of books and technical journals, are clearly and concisely covered. Particular attention has been given to such subjects as transmission of alternating currents, storage batteries, lightning arresters, electric lighting and electric railway. At the same time tables and formula for calculating resistance, length of spans for overhead wiring, proper design for electro-magnets, designing motors and dynamos and transformers, and a large range of other electrical subjects are included. Lengthy and complicated descriptions have been omitted and the book as it stands represents the essence of electrical engineering practice of to-day. We unhesitatingly recommend the book to our readers as a valuable addition to any general engineering library as a book of reference, but more particularly to those of our readers who are using electricity in one form or another.

Compressed Air Machine for Making Glass.

At the old DePauw factory at Alexandria, Indiana, the veil of secrecy has been lifted, the high board fence which inclosed the factory has been pulled down, and the public have been admitted. The final test of the glass-blowing machines just completed promises to do something toward revolutionizing the glass-making industry.

On questioning Mr. DePauw after the test, he said:

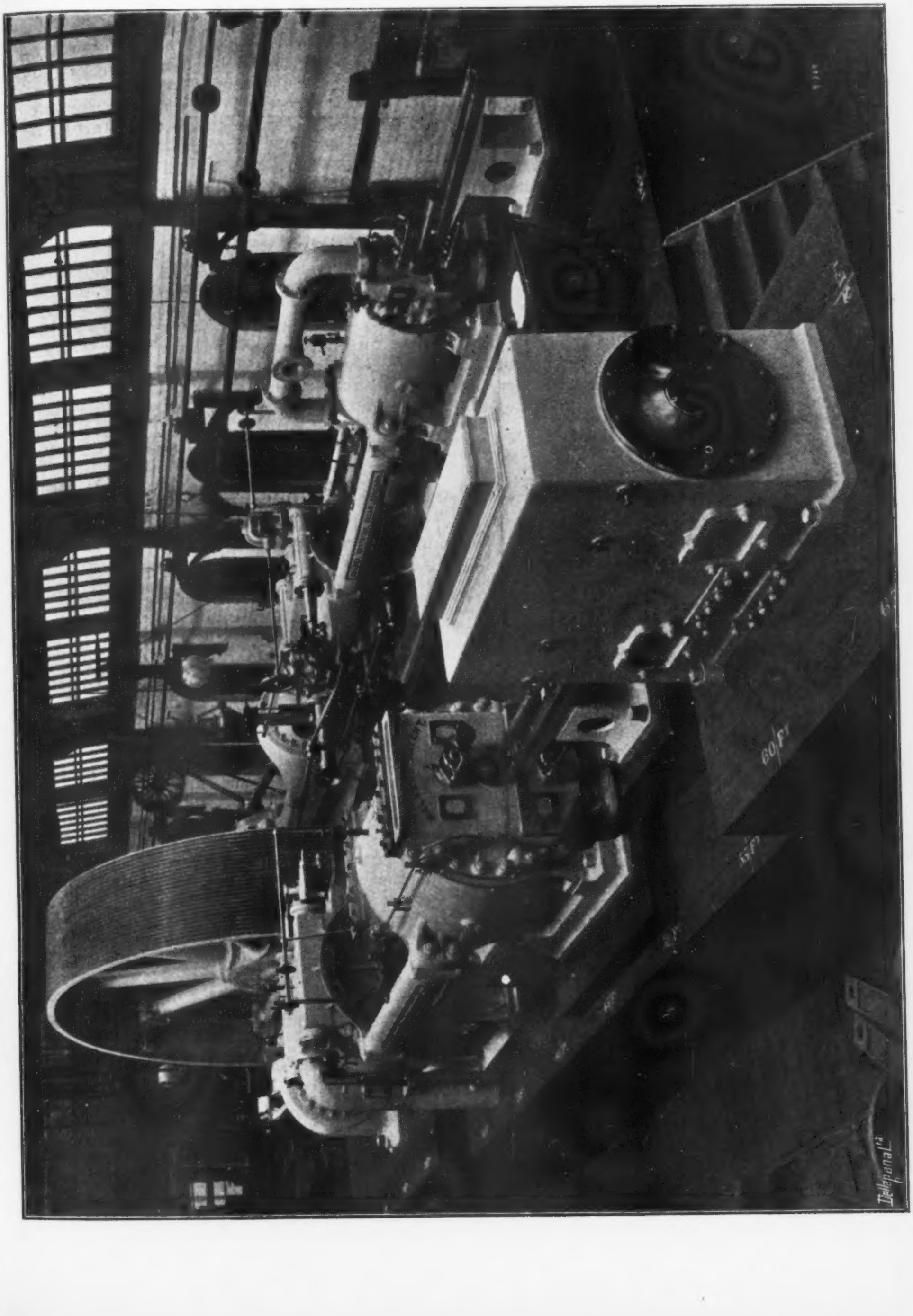
"There has been a general misconception in regard to the matter of secrecy. The company have not been testing the machine itself—that was done long ago, but we have been endeavoring to find the cheapest method of operating the machine. Our main reason for secrecy has been that we have not until recently secured patents on our apparatus. It is very simple and the only thing wonderful about it is the fact that the process was not perfected long ago. This will be to the glass trade what the linotypes have been to the newspaper business.

"The patents provide, in substance, for a tank furnace having a force-hearth extension. A vertically moving frame on which is rigged the blowing pipe is placed over this extension. Compressed air is then admitted to the pipe. When drawn to the required length, the cylinder is withdrawn from the mass of glass by the insertion of heat currents. This accomplished—all automatically—the glass is swung to one side and is drawn from the drawing tool and put through the finishing process exactly as the glass from the blower's pipe heretofore. The apparatus is, in truth, merely a sort of ingenious device for the operation of an automatic condensed air mechanism. It was built, it would appear, to apply the force of compressed air to the molten sand exactly as the blower applies it from his lungs."

It was further stated at the completion of the experiment that the machines can be built cheaply, that enough will be procured and in operation by the time of the renewal of the fires later on to do away with a number of blowers at once.

Compressor at Ooregum Gold Mine.

The air compressor herewith shown has been supplied by Messrs. Walker Bros., of Wigan, and is in operation at the Ooregum Gold Mining Co., of India, Ltd. It is intended to operate rock drills and other machinery. There are about forty drills, mostly Climax pattern, at work in this mine, most of which are under the charge of the natives. Formerly Italian miners were largely employed in working the rock drills, but European operators are now no longer necessary, as the natives have



NEW AIR COMPRESSOR AT THE OCREGUM GOLD MINE.

been trained to handle the machines with efficiency.

The Ooregum Mine started into existence January, 1881, but prior to that date it was owned and worked by a Madras company, with a somewhat similar name. It is situated in the heart of the Kolar mining area, being bounded on the south by the Champion Reef and on the north by Nundydroog.—Supplement of *The Mining World.*

Notes.

The McKiernan Drill Co. announce the removal of their New York office to 170 Broadway. They have also moved their works to Dover, N. J.

Compressed air can be used directly for ventilation, refrigeration, drying or operation of elevators. It is not a rival of electricity, but has its field as one of the great motive powers, the same as the steam or gas engine.

If a volume of air at sixty pounds pressure, equivalent to 18,000 cubic feet per hour at atmospheric pressure, be passed through 1,000 feet of pipes, the loss of pressure of air for 2½-inch, 3-inch and 3½-inch pipes would be 5¾ pounds, 2 pounds and 1½ pounds, respectively.

The Pedrick & Ayer Company is exceedingly busy, and much hampered for want of room. The air compressor department is much taxed, and the orders for pneumatic hoists find the department for such goods entirely inadequate. The company has not yet placed its orders for the power equipment of its new plant at Garwood, N. J.

The plans for the new plant of the Cleveland Pneumatic Tool Company are just about completed, and contracts will be let at an early day for the construction of the buildings. The Company has just opened up an office at No. 411 Park Bldg., Pittsburg, Pa., represented by Chas. L. Nelson, and at No. 34 Lemoine St., Montreal, Canada, represented by N. J. Holden & Company.

A machine cannot give off more power than is put into it in one form or another; the power given off is always represented by a fraction, that put into it being unity. This is due to the losses within the machine itself—that is, it takes some power to run the machine alone so that the power given off will be equal to that put into it minus the amount required to run the machine itself.

The lifting power of any gas is the difference between the weight of the gas and the weight of the same volume of air. One cubic foot air at normal pressure weighs 1.29 ounce avoirdupois; one cubic foot pure hydrogen under the same conditions weighs 0.089 ounce avoirdupois. The difference is 1.2 ounce, which is the weight that one cubic foot of hydrogen will balance in the air. It will lift any weight less than that.

At sea level 1,000 cubic feet of air compressed to 80 pounds in two stages develops 1,000x.137=137 horse-power at an altitude of 10,000 feet above sea level, the volume to be equivalent at this pressure must be 39 per cent. greater, or 1,390 cubic feet. At that altitude the horsepower factor for compression to 80 pounds is .113 per cubic foot; so 1,390x.113=157 horse-power. Hence 20 horse-power more than at sea level is required for the same effect.

The Caskey Portable Pneumatic Punch is described and its advantages set forth in a pamphlet just issued by F. F. Slocomb & Co., Wilmington, Del. The essential features of this punch are: The hollow ball piston and oil intensifier. But one charge of air is required for the backward and forward motion of the piston. Several shop views show the application of the punch to various classes of work. Illustrations of several standard designs, together with descriptive tables, are given.

Steam Hammers.—We have just received from Bement, Miles & Co., Philadelphia, Pa., a catalogue illustrating their various forms of steam hammers. In this no attempt is made to describe the machines in detail and the book is confined to a series of full-page illustrations of the several sizes of hammers which they make and very brief descriptions. We call this to the attention of the readers of Com-

PRESSED AIR, because in many instances hammers of this sort are being operated by compressed air and the subject is one which opens up possibilities which may be of interest to some of our readers.

Westinghouse, Church, Kerr & Co. are pleased to announce the removal of their Pittsburg office from its former location on the first floor of the Westinghouse Building to more commodious quarters on the eighth floor of the same building. This change is the direct outcome of largely increased business in this district, and is accompanied by the organization of two new departments, viz., Engineering and Construction Departments, in addition to the original Sales Department, and the acquirement of a commodious reception-room devoted exclusively to the convenience and entertainment of visitors and patrons.

The Philadelphia Pneumatic Tool Company has established an agency in South Africa, with headquarters at Johannesburg. It will be in charge of Gen. Samuel Pearson, late of the Boer forces. General Pearson has been in the United States for some months in the interest of his government, in the attempt to have the mule shipments from Port Chalmette stopped. Now that peace has been declared he will return to his former business in machinery lines and will handle the accounts of the Philadelphia Pneumatic Tool Company and others. Before coming to America General Pearson saw much active service in the field, and for a time was in charge of railroad traffic.

In producing compressed air a great difficulty is the question of heat, which increases as the pressure increases. Formerly, whatever pressure was required, the whole operation was performed in one cylinder, and for high pressures the amount of heat produced was far too great to be dealt with effectively. The result was that the heat generated expanded the air, and we not only lost the heat, but the expanded air required an increased amount of mechanical work, which was also lost. In the compound system we divide the compression into two stages in two cylinders, thus having a less amount of heat to deal with in one operation, and we can deal with it with better effect. The intermediate cooler between the stages is a vital part of the arrangement.

Air, and compressed air at that, is beginning to supersede towels in the equipment of the well-regulated barber shop. After the shaving process has been concluded the tonsorial artist in an uptown Broadway establishment carefully sponges from the customer's visage all traces of soap. Then he reaches under the shelf and draws forth a piece of rubber hose the end of which is tipped by a metallic contrivance. This is affixed to the atomizing apparatus of a bottle of bay rum. A button is pressed and a fine spray of the cooling liquid is directed at the face of the customer. A sharp click and the pipe is disconnected to be reaffixed to a bottle of the regulation toilet water.

Then the barber massages the face for a few minutes and concludes by reaching for the rubber pipe once more. This time there is no attaching it to a bottle. The current of air is directed at the face, and in less time than it would take with a towel the features are dried. The sensation of the air pouring across the mouth and nostrils is apt to cause a gasp or two from the prostrate victim in the chair, but after he has passed through the ordeal once or twice he is prepared for the emergency and the sensation is rather pleasing than otherwise.—*New York Press.*

U.S. PATENTS GRANTED JUNE, 1902

Specially prepared for COMPRESSED AIR.

701,327. CONTINUOUS AUTOMATIC AIR-BRAKE SYSTEM. Edward L. Gosse, Chanute, Kans., assignor of one-half to Louis A. Laughlin, Kansas City, Mo. Filed Nov. 1, 1901. Serial No. 80,758.

701,359. AIR-SHIP. Carl F. A. Klotz, Indianapolis, Ind. Filed July 8, 1901. Serial No. 67,430.

701,506. METHOD OF TREATING AIR FOR COOLING AND MOISTENING SAME. William P. Rice, Chicago, Ill. Filed Feb. 25, 1901. Serial No. 48,635.

The process which consists in inducing a current of air directly from a source of natural humidity to or through a space to be cooled, placing a gas under compression to materially reduce its volume, removing the heat of compression from said gas, permitt the cooled and compressed gas to expend into said current of air, and delivering into th

path of the expanding gas water in such quantity that the expanding gas acts to atomize the water and disseminate the same through the air-current in the form of a mist or fog; the said air-current being supplied from a natural source in such quantity and humidity that the particles of liquid forced or carried thereinto by the expanding gas are at once evaporated and the air-current is thereby cooled and at the same time suitably humidified.

701,510. AIR-SHIP. Peter Samorski, Chicago, Ill. Filed Dec. 9, 1901. Serial No. 85,219.

701,580. PNEUMATIC-SURFACER FRAME. Herman G. Kotten, New York, N. Y. Filed July 17, 1901. Serial No. 68,592.

A post, an arm rotatably mounted thereon, a drum carried by said arm, rollers carried by said post and arm, a connection passing around said rollers and leading from an end of said arm to said drum, and means for rotating the latter, in combination with a carriage mounted on said arm, trolleys on the upper and lower portion of said carriage adapted to contact with tracks on said arm, and a set of rollers mounted in the lower portion of said carriage and adapted to contact with the lower of said tracks.

701,796. AIR-BRAKE APPARATUS. William L. Clark, Oelwein, Iowa. Filed Dec. 30, 1901. Serial No. 87,743.

701,869. PNEUMATIC-DESPATCH SYSTEM. Hugo W. Forslund, Chicago, Ill., assignor to the American Pneumatic Service Company, Boston, Mass., a Corporation of Delaware. Filed Sept. 28, 1899. Serial No. 731,930.

701,981. AUTOMATIC AIR-BRAKE. Granville T. Woods, New York, N. Y., assignor, by mesne assignments, to the Westinghouse Air-Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Feb. 5, 1901. Serial No. 46,080.

702,124. FLUID-PRESSURE BRAKE APPARATUS. Nathan J. Benton, New Decatur, Ala., assignor of one-half to William P. Thomas, Birmingham, Ala. Filed May 8, 1901. Serial No. 59,306.

702,268. APPARATUS FOR APPLYING AND CONTROLLING BRAKING FORCE. Henry H. Westinghouse, Pittsburg, Pa., assignor to the Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Nov. 14, 1892. Serial No. 451,937.

702,324. AIR-LOCK FOR CAISSONS. William McIlvrid, Jersey City, N. J. Filed Apr. 14, 1902. Serial No. 102,903.

An air-lock for caissons, comprising a casing having exterior lateral extensions, upper and lower gates, and means for actuating said gates located outside of the casing within the vertical planes of said lateral extensions, and connected within the casing of the gates.

702,367. PNEUMATIC-TRANSFER-TUBE SYSTEM. Francis W. Jones, New York, N. Y., assignor to the Transfer Tube Company, New York, N. Y., a Corporation of New York. Filed Apr. 25, 1902. Serial No. 104,605.

702,374. AIR SUPERHEATER OR CARBURETER. Harry M. McCall, Pittsburg, Pa., assignor to Pittsburg Gas Engine Company, Pittsburg, Pa. Filed Mar. 7, 1902. Serial No. 97,079.

702,497. FLUID-PRESSURE COUPLING. William H. Simmons, Alexandria, Va. Filed Nov. 8, 1901. Serial No. 81,593.

702,529. APPARATUS FOR SUPPLYING AIR AND HYDROCARBON. William N. Best, Los Angeles, Cal., assignor of two-thirds to John H. Best and Ezra Best, Quincy, Ill. Filed June 3, 1901. Serial No. 62,907.

702,931. PNEUMATIC RAILWAY SWITCH AND SIGNAL APPARATUS. Frank L. Dodgson, Rochester, and Murray Corrington, New York, N. Y., assignors to International Pneumatic Railway Signal Company, Rochester, N. Y., a Corporation of West Virginia. Filed Oct. 26, 1901. Serial No. 80,107.

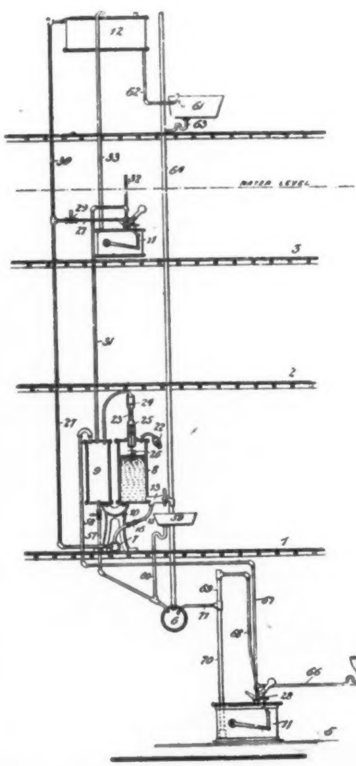
702,979. PNEUMATIC HOIST. George E. Martin, Philadelphia, Pa., assignor to the Pedrick and Ayer Company, Philadelphia, Pa. Filed Aug. 15, 1901. Serial No. 72,114.

A fluid-pressure hoist comprising a cylinder, piston and piston-rod, a constant fluid-pressure communication to one side of the piston, a communication between both sides of the piston and a double valve device mounted in a single casing for controlling the admission of fluid-pressure to one side of the piston, its exhaust therefrom and automatically regulating the escape of pressure to hold the piston in its moved position.

702,994. APPARATUS FOR COOLING AND AGITATING AIR. Edwin F. Porter, Boston, Mass., assignor to the Bay State Electric Heat & Light Company, Jersey City, N. J., a Corporation of New Jersey. Filed Dec. 20, 1897. Serial No. 662,540.

An apparatus of the class described, a rotatable fan for creating a current of air and having passages leading through the same, a receiver for containing a cooling medium, a chamber leading from said receiver and connected with the passages in said fan, a chamber leading to said receiver and connected with the passages in said fan, and means for forcing the cooling medium through the passages of the fan, the chambers and the receiver.

703,045. APPARATUS FOR RAISING LIQUIDS. Gustavis L. Cudner and John Dyer, New York, N. Y. Filed June 5, 1901. Serial No. 63,203.



An apparatus for raising liquids, a liquid-elevating tank, a liquid-elevating pipe leading therefrom, a liquid-feed pipe, an air-vent pipe, a compressed-air-feed pipe, a controlling-valve for the liquid-feed, air-vent and compressed-air-feed pipes, and means for operating said valve comprising a float, a rocking lever loosely mounted on the valve-stem connected to the float, a two-armed lever fixed to the valve-stem and an intermediate weighted lever loosely mounted on the valve-stem in position to be engaged by the lever connected to the float for causing the weighted lever to engage the lever connected with the valve-stem.

703,078. PNEUMATIC STACKER. Frederick L. Norton, Racine, Wis. Filed Mar. 8, 1902. Serial No. 97,230.

703,120. PNEUMATIC-CARRIER SYSTEM. Willis W. Danley, Chicago, Ill., assignor to American Pneumatic Service Company, Boston, Mass., a Corporation of Delaware. Filed July 30, 1900. Serial No. 25,246.